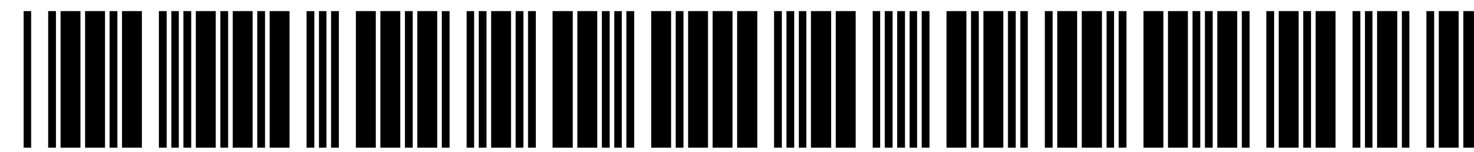

(12) **United States Patent**
Kato et al.

(10) **Patent No.: US 10,433,470 B2**
(45) **Date of Patent: Oct. 1, 2019**

(54) **CARRIER TAPE, METHOD FOR MANUFACTURING SAME, AND METHOD FOR MANUFACTURING RFID TAG**

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(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/679,333**

(22) Filed: **Aug. 17, 2017**

(65) **Prior Publication Data**

US 2017/0367226 A1 Dec. 21, 2017

Related U.S. Application Data

(60) Division of application No. 15/234,193, filed on Aug. 11, 2016, now Pat. No. 9,775,270, which is a (Continued)

(30) **Foreign Application Priority Data**

Nov. 7, 2014 (JP) 2014-227195
Nov. 27, 2014 (JP) 2014-239824
(Continued)

(51) **Int. Cl.**
H05K 13/00 (2006.01)
G06K 19/07 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H05K 13/003*** (2013.01); ***G06K 19/07*** (2013.01); ***G06K 19/077*** (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 235/492
See application file for complete search history.

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Kato et al., "Carrier Tape, Method for Manufacturing Same, and Method for Manufacturing RFID Tag", U.S. Appl. No. 15/234,193, filed Aug. 11, 2016.
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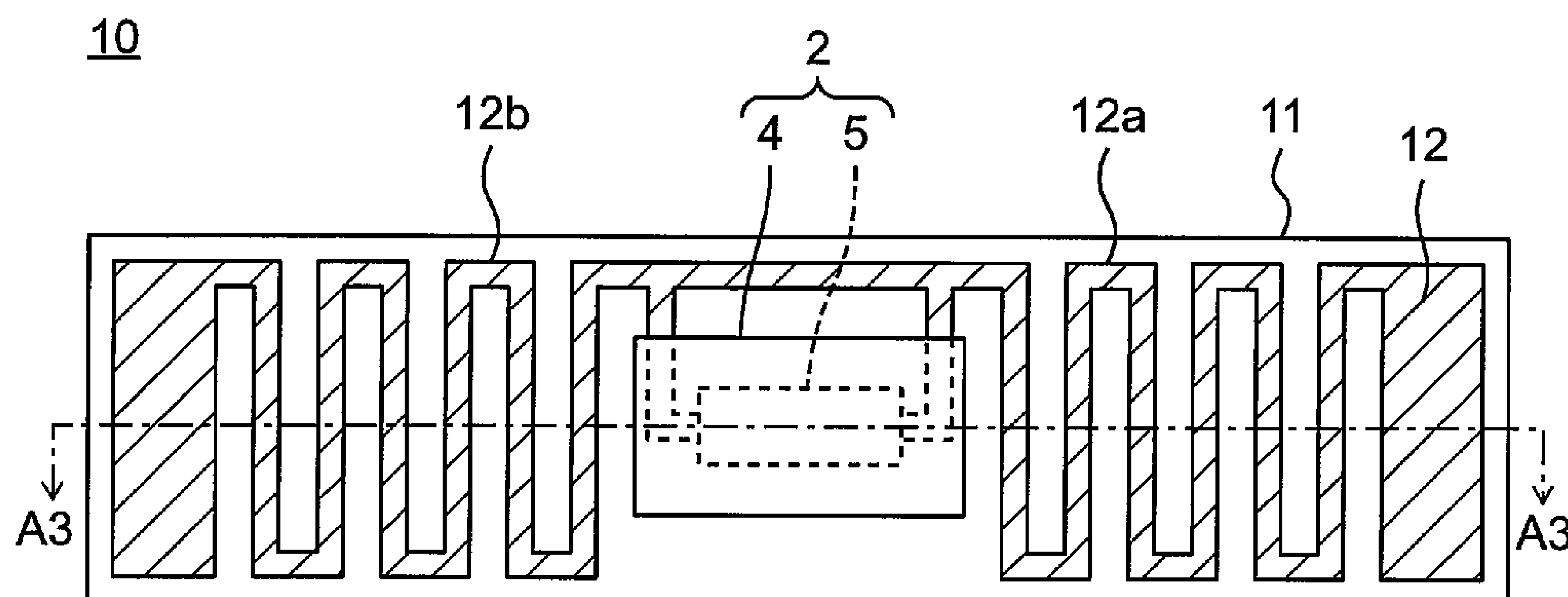
Primary Examiner — Rafferty D Kelly
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

A method for manufacturing a carrier tape housing a plurality of electronic components with seal materials includes forming housing holes in tape-shaped main body with first and second principal surfaces along a longitudinal direction of the tape-shaped main body, the housing holes penetrating from the first principal surface to the second principal surface, affixing an adhesive layer of a tape-shaped seal material to the second principal surface of the tape-shaped main body to cover the housing holes, forming cuts in the tape-shaped seal material to separate portions defining and functioning as the seal materials including portions at least partially overlapping with the respective housing holes in a planar view from the other portions, and providing chip-shaped electronic component into each of the housing holes
(Continued)



of the tape-shaped main body and fixing the electronic component to the adhesive layer of the seal material exposed in each of the housing holes.

9 Claims, 15 Drawing Sheets

Related U.S. Application Data

continuation of application No. PCT/JP2015/080012, filed on Oct. 23, 2015.

(30) **Foreign Application Priority Data**

Feb. 19, 2015 (JP) 2015-030318
Mar. 6, 2015 (JP) 2015-044178
May 19, 2015 (JP) 2015-102092

(51) **Int. Cl.**
G06K 19/077 (2006.01)
G09F 3/00 (2006.01)
H01Q 1/22 (2006.01)
H05K 1/18 (2006.01)

(52) **U.S. Cl.**
CPC ... ***G06K 19/0776*** (2013.01); ***G06K 19/07775*** (2013.01); ***G09F 3/00*** (2013.01); ***H01Q 1/2208*** (2013.01); ***H05K 1/185*** (2013.01); *H05K 2201/10098* (2013.01)

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Fig.1

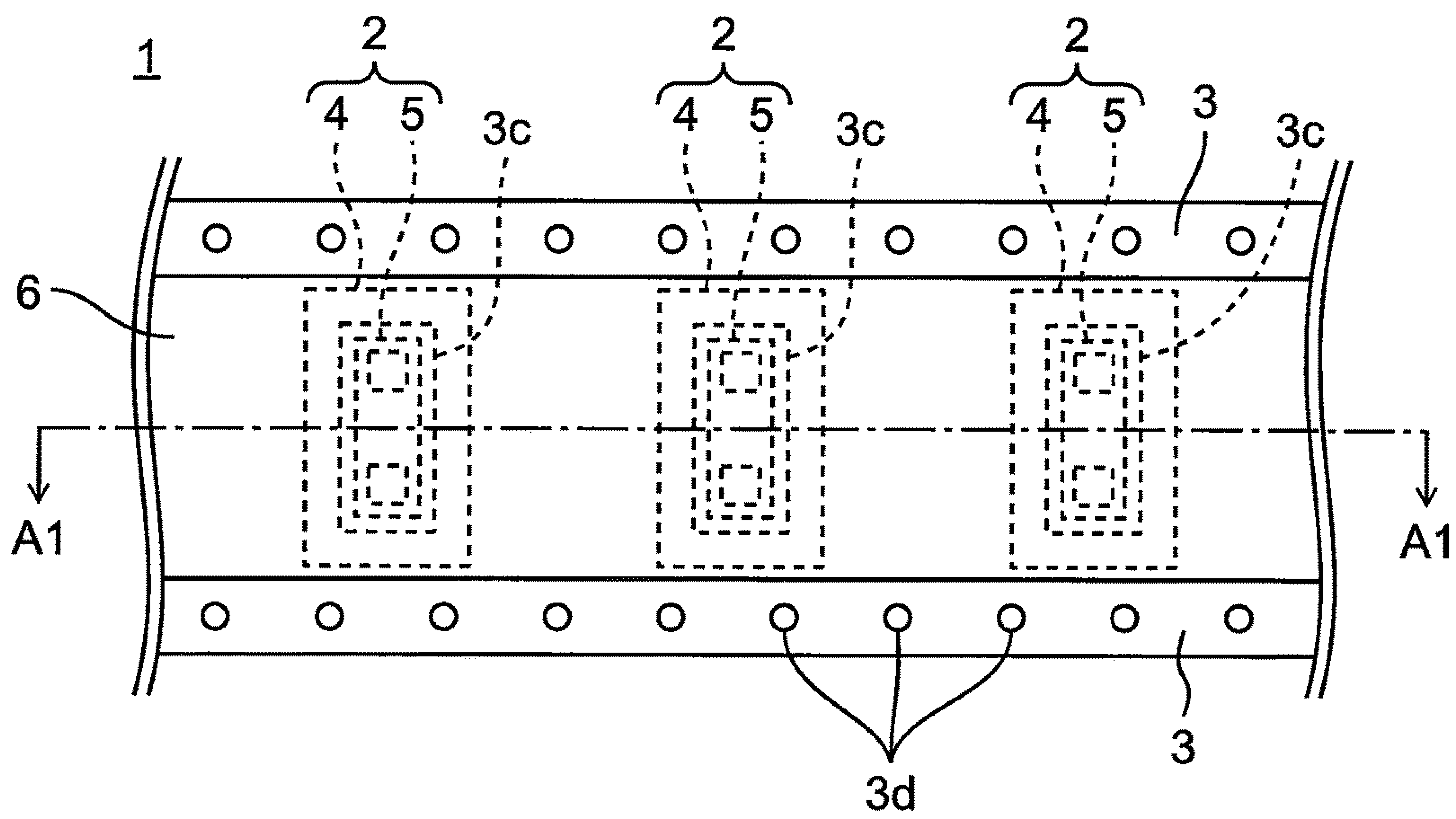


Fig.2

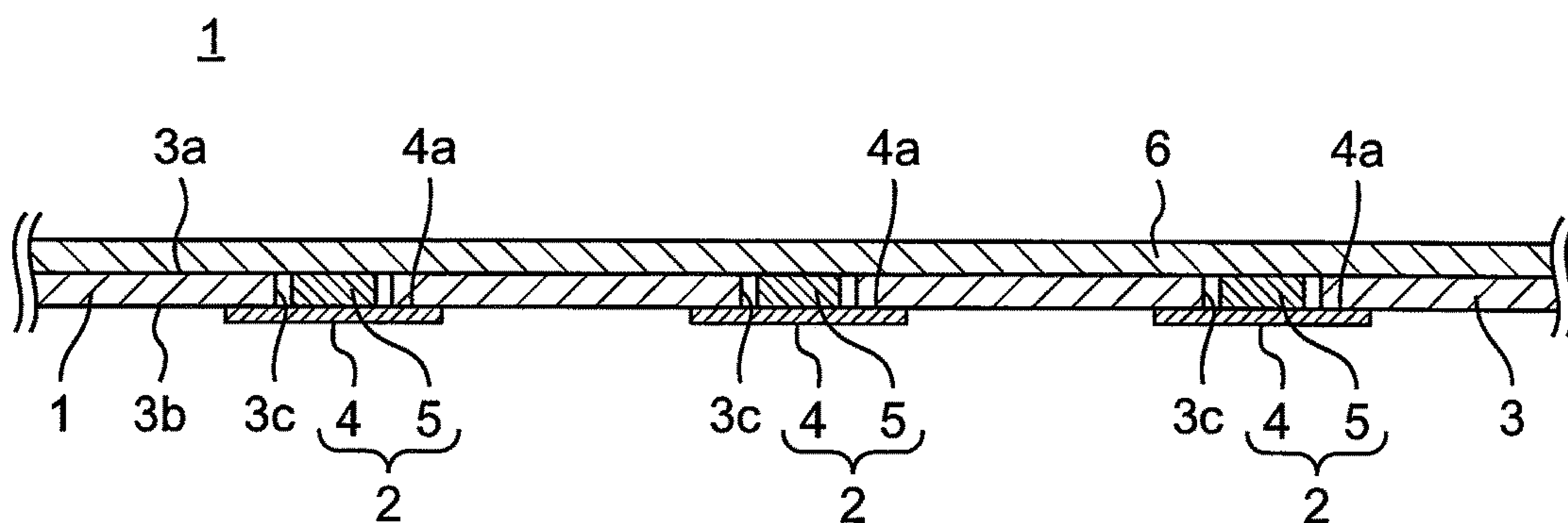


Fig.3

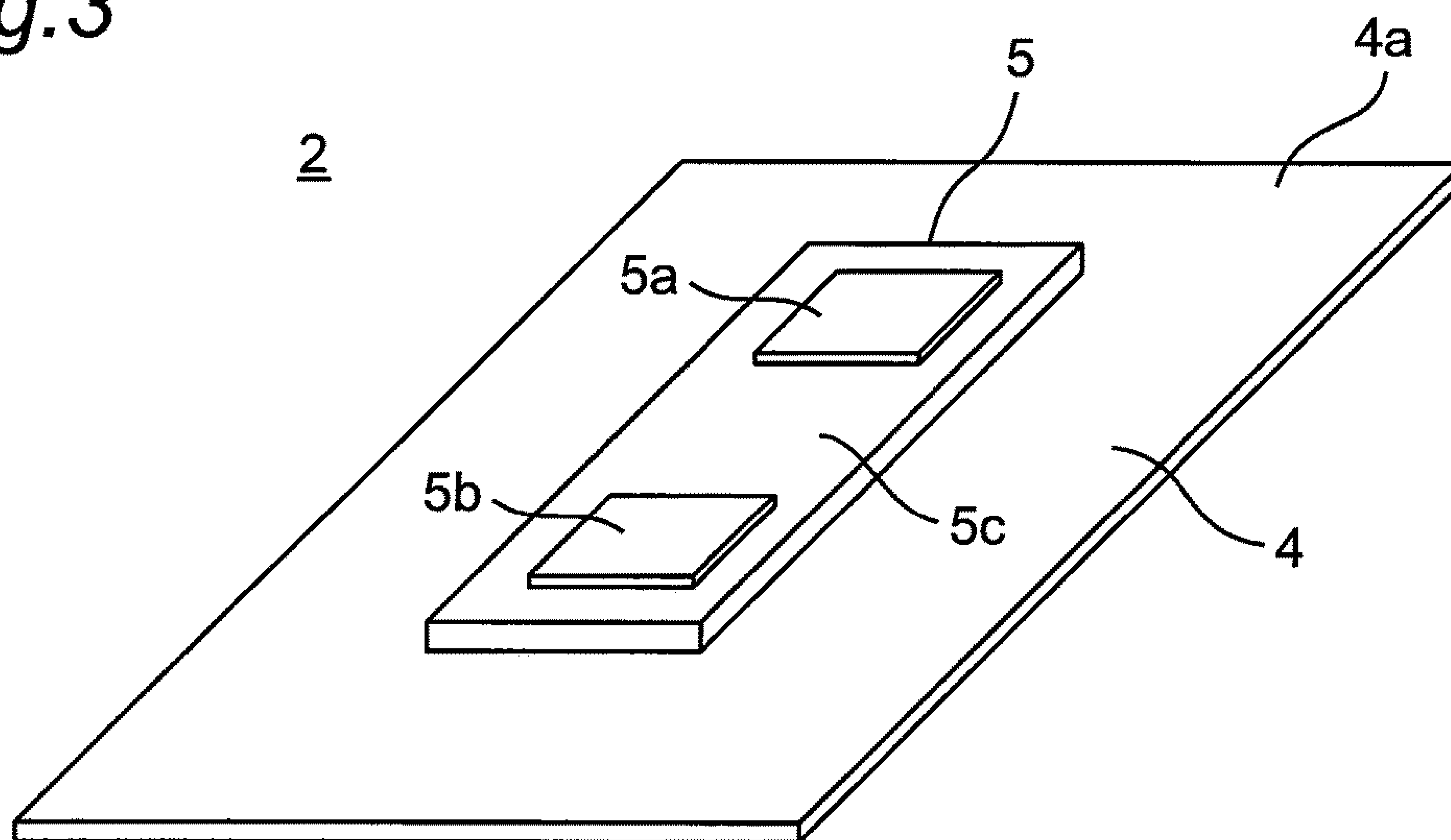


Fig.4A

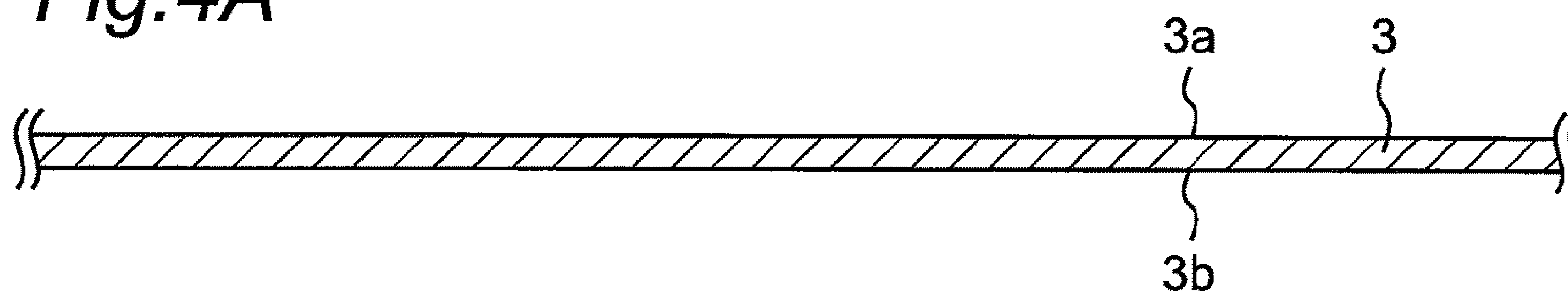


Fig.4B

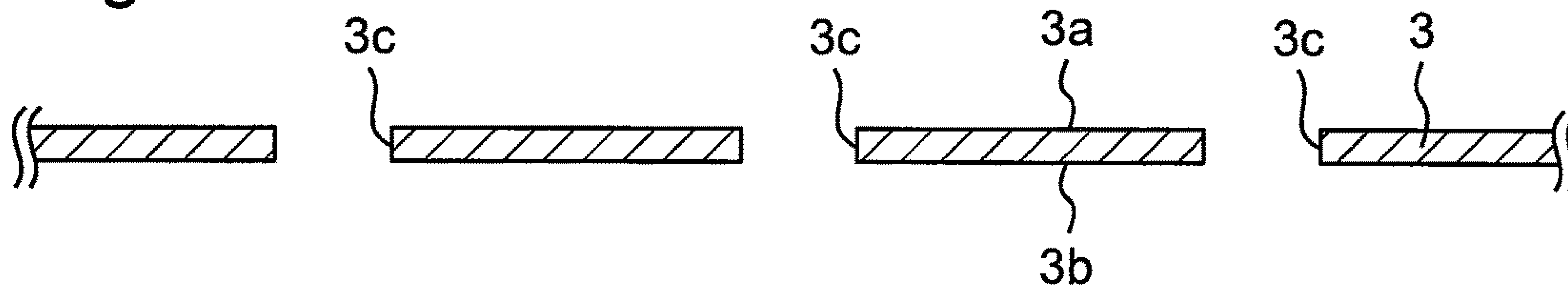


Fig.4C

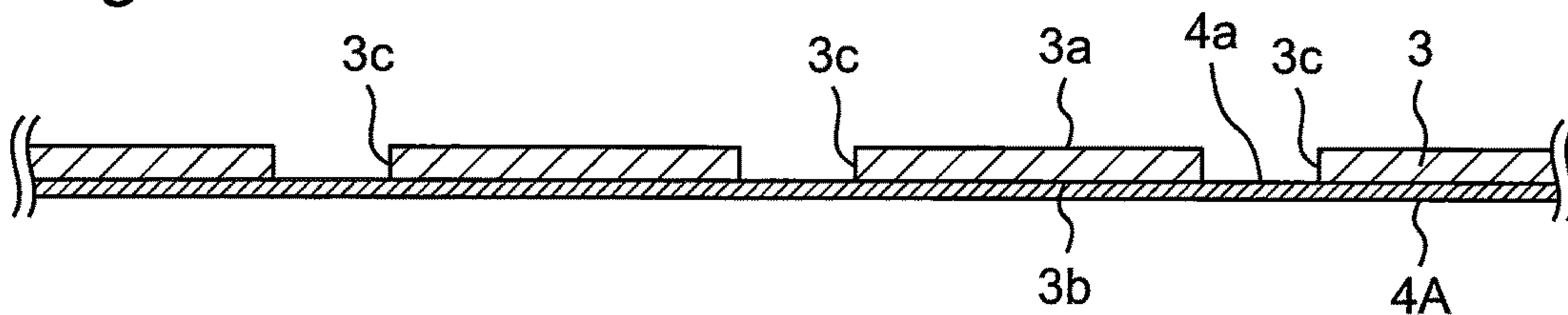


Fig.4D

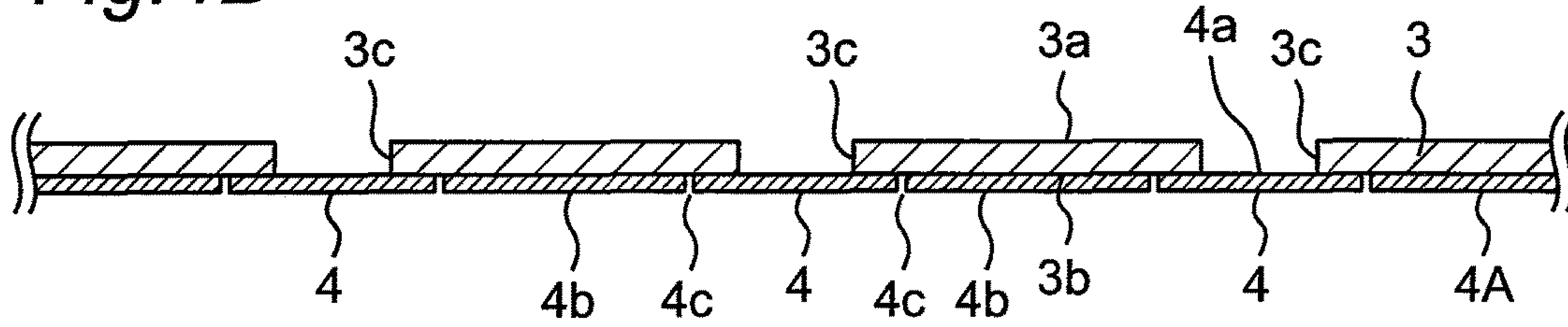


Fig.4E

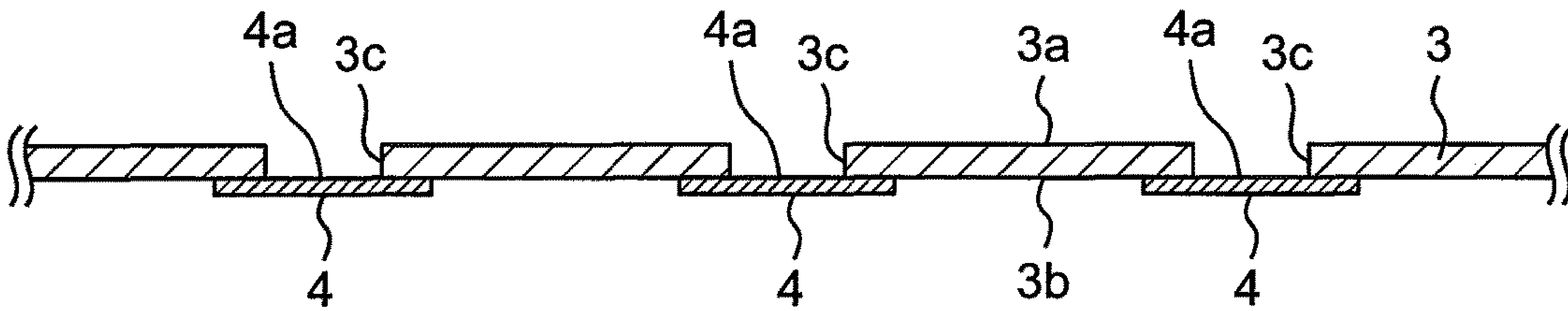


Fig.4F

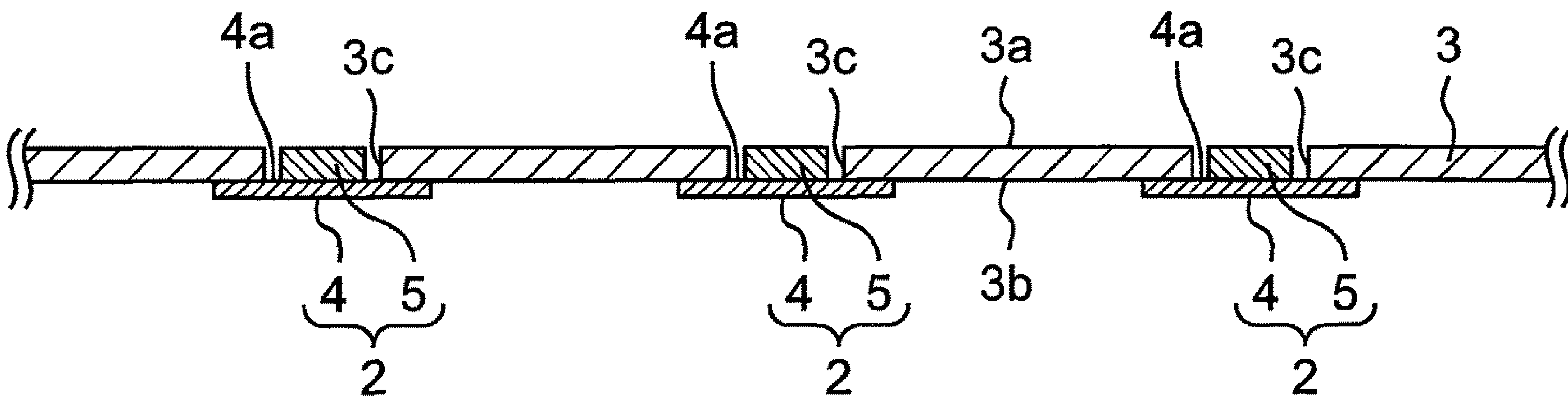


Fig.4G

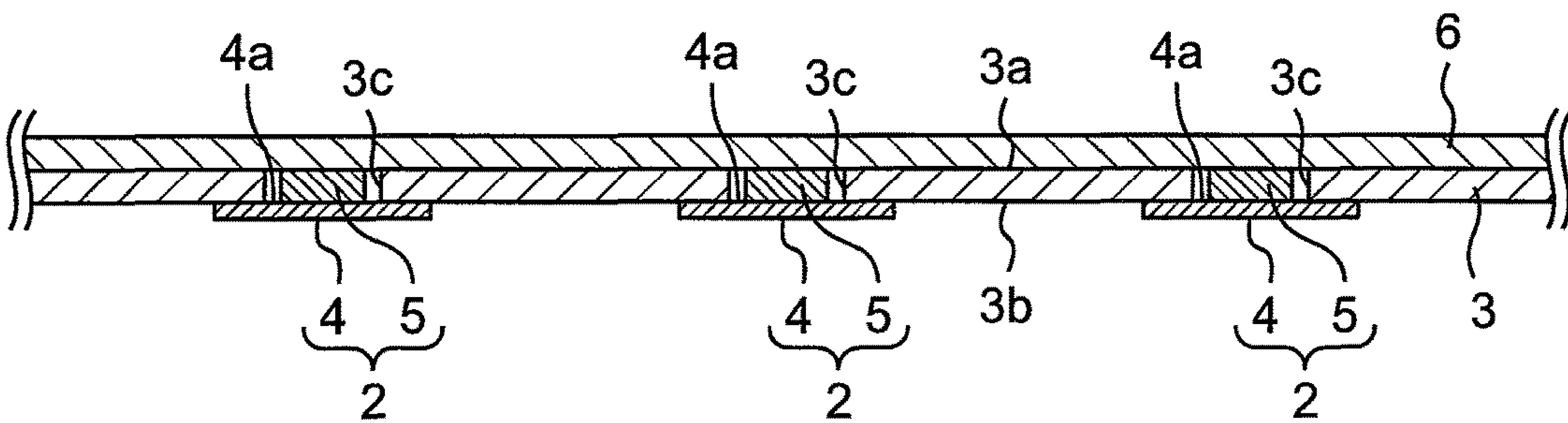


Fig.5

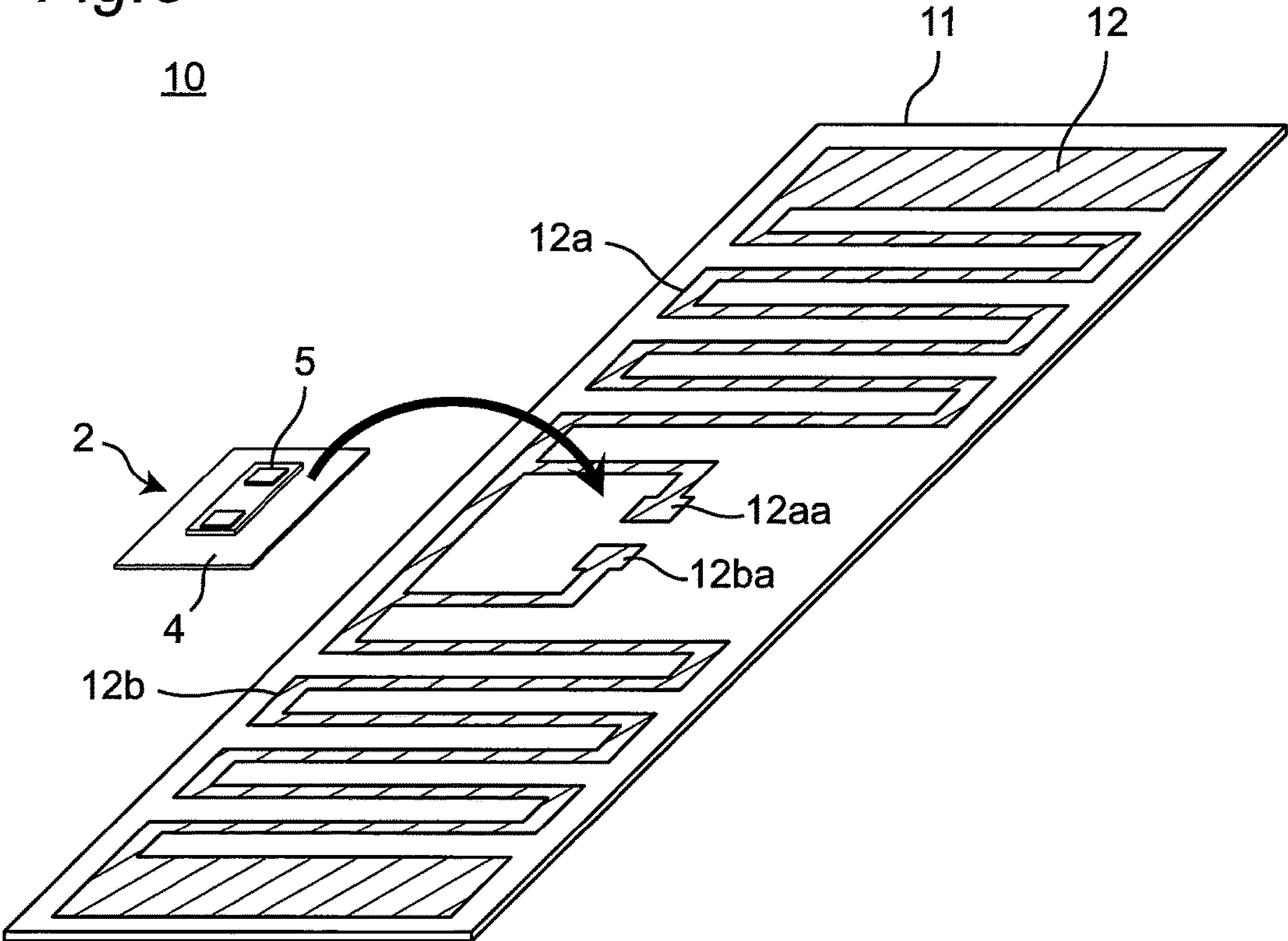


Fig.6

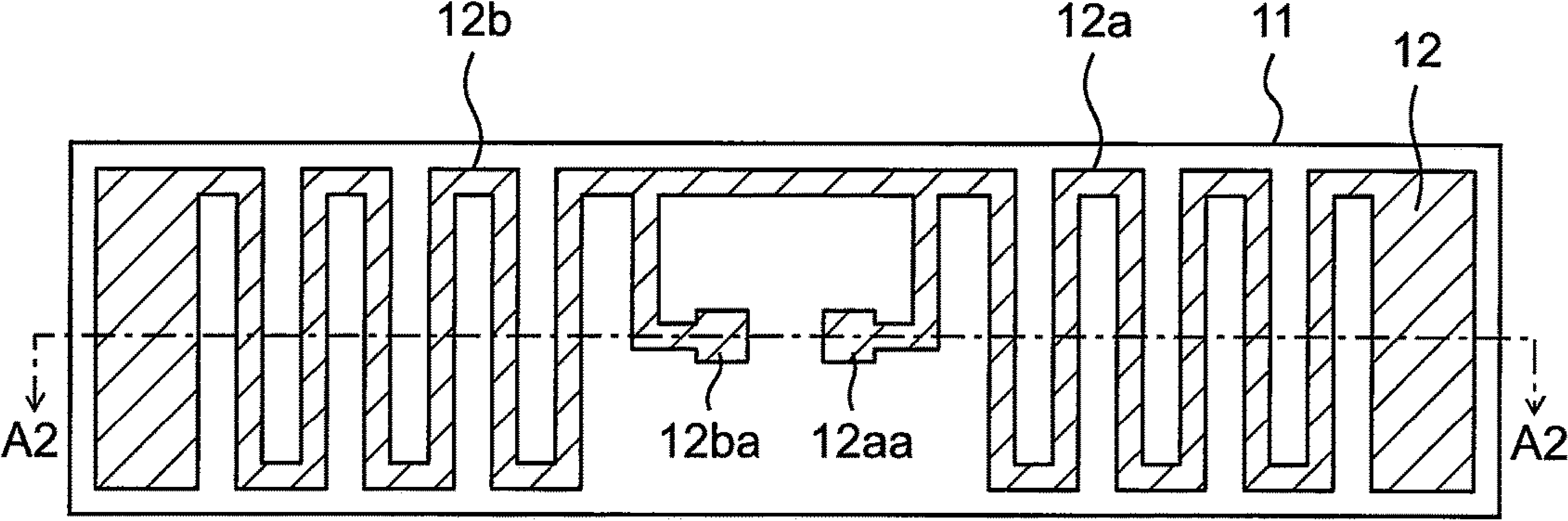


Fig.7

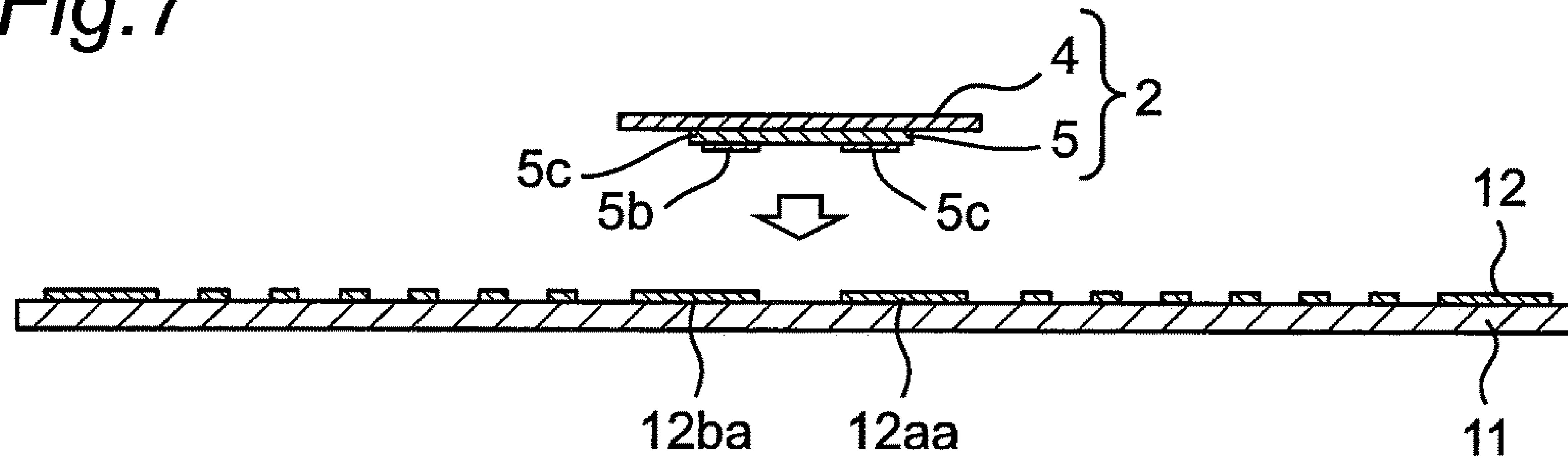


Fig.8

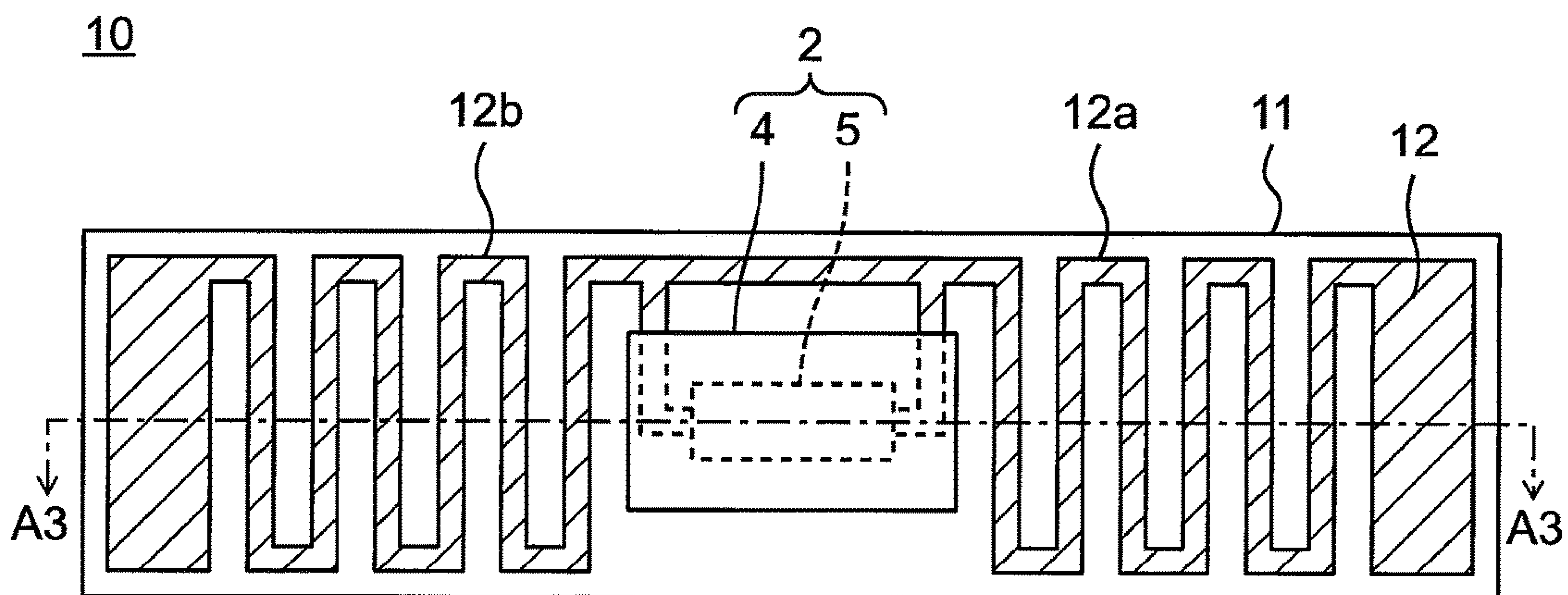


Fig.9

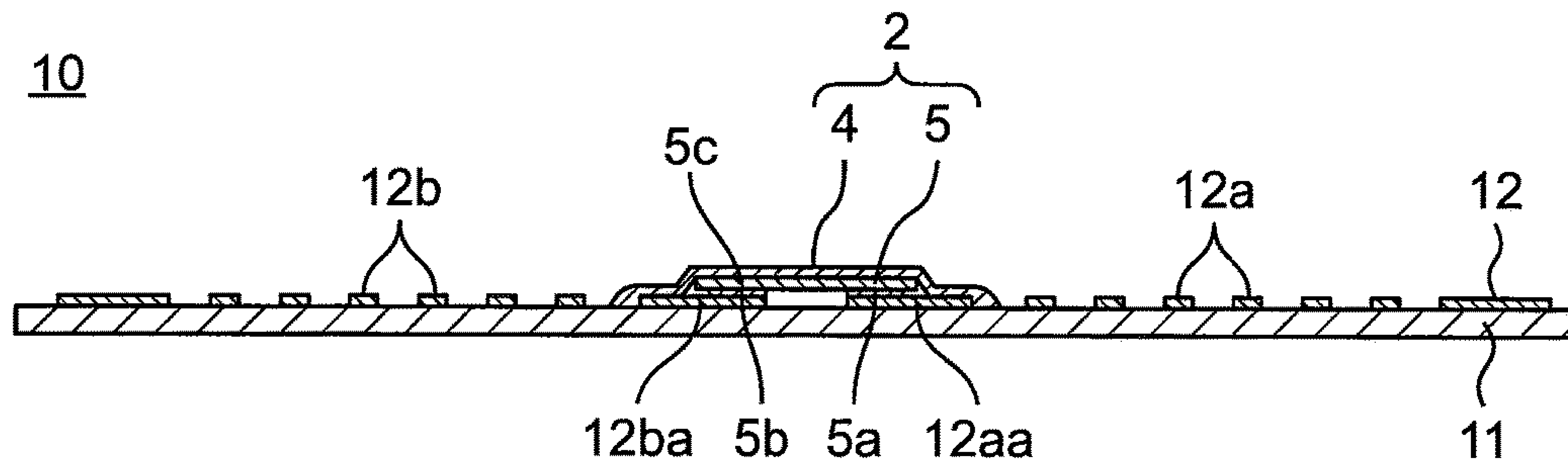


Fig.10

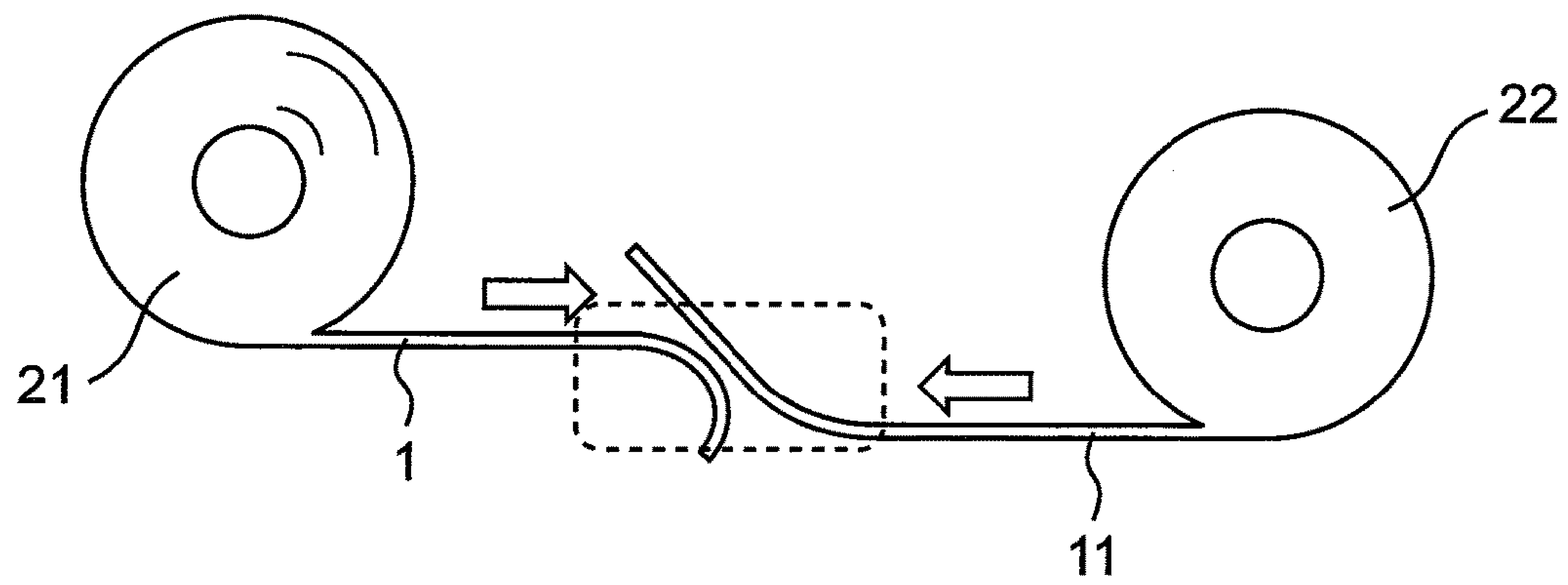


Fig.11

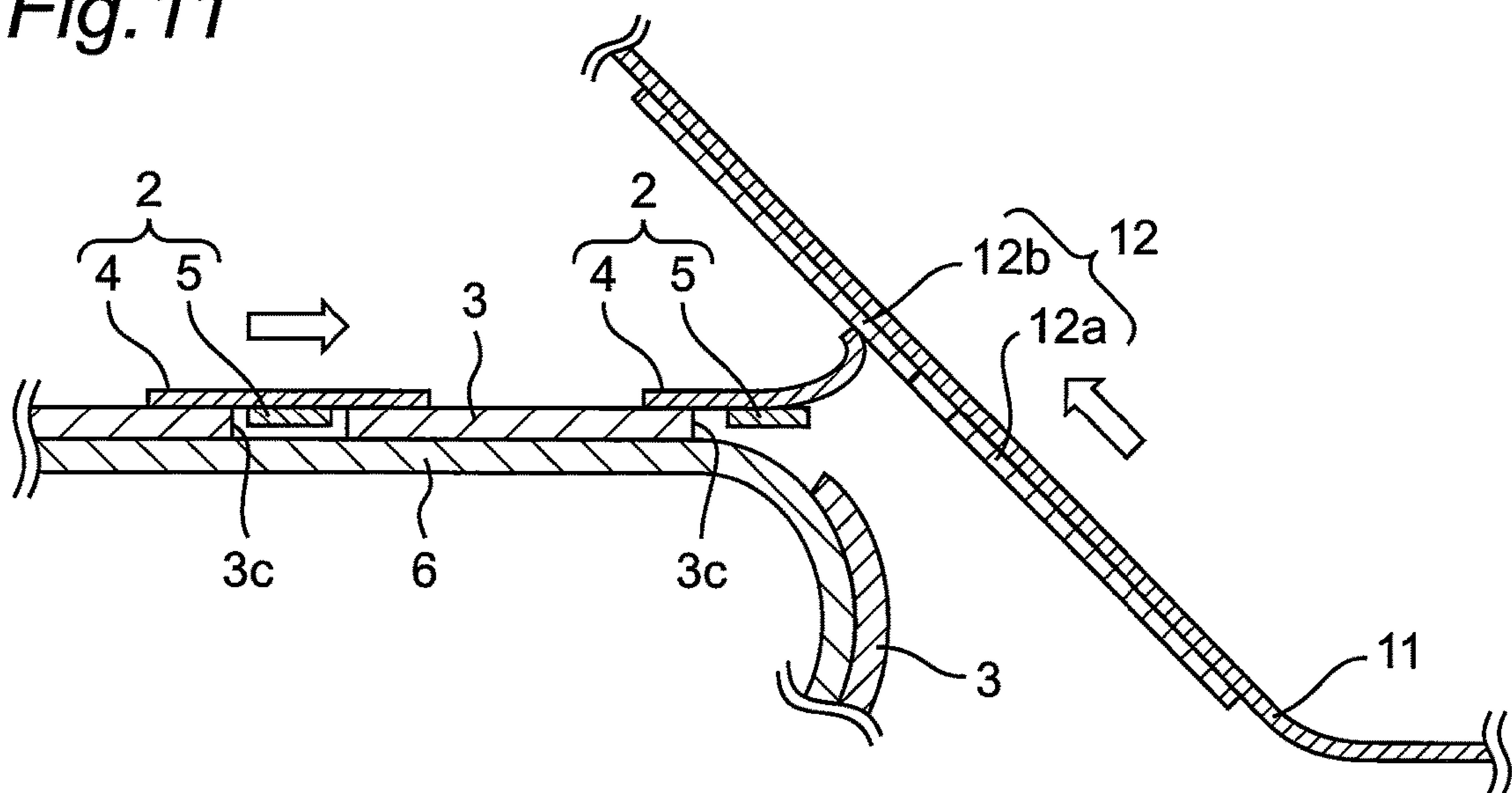


Fig. 12

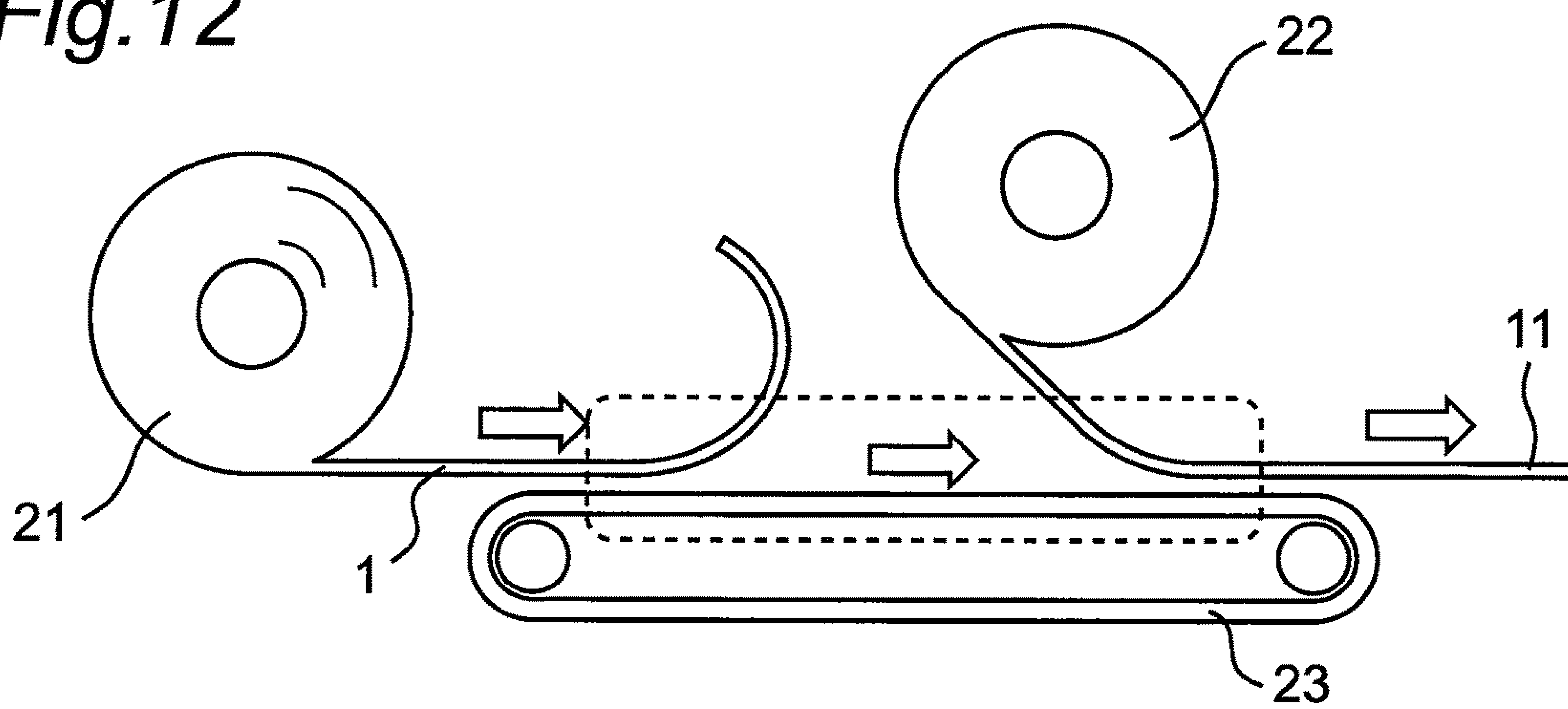


Fig. 13

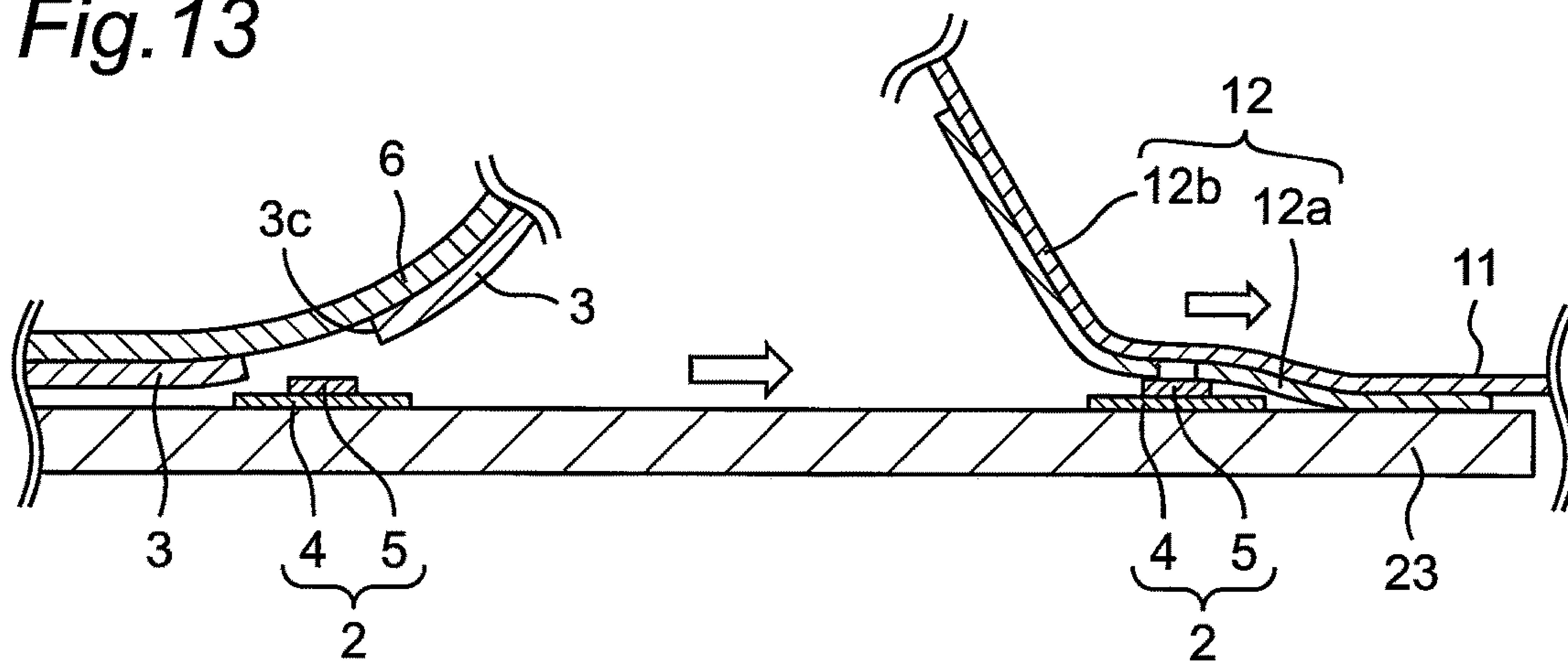


Fig.14

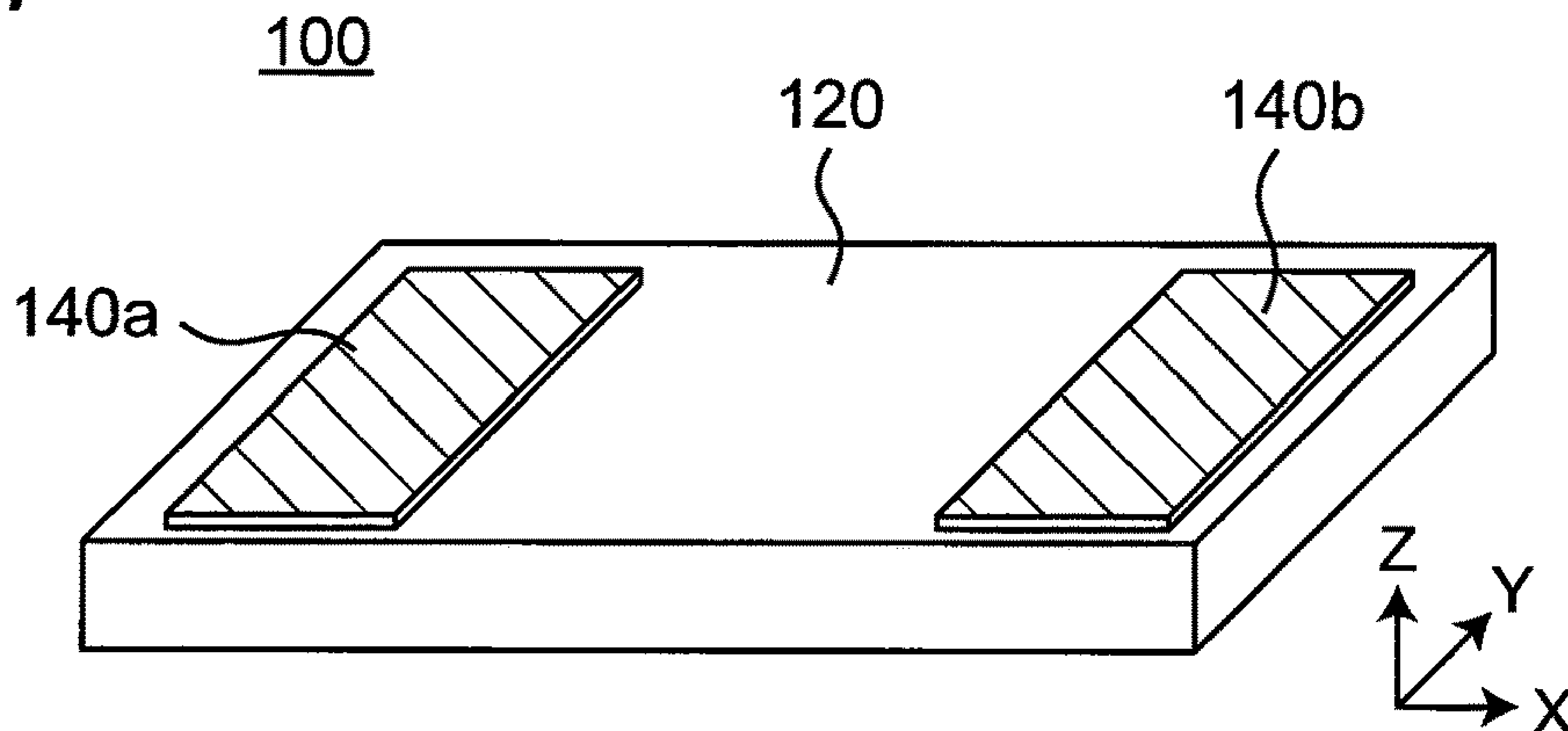


Fig.15

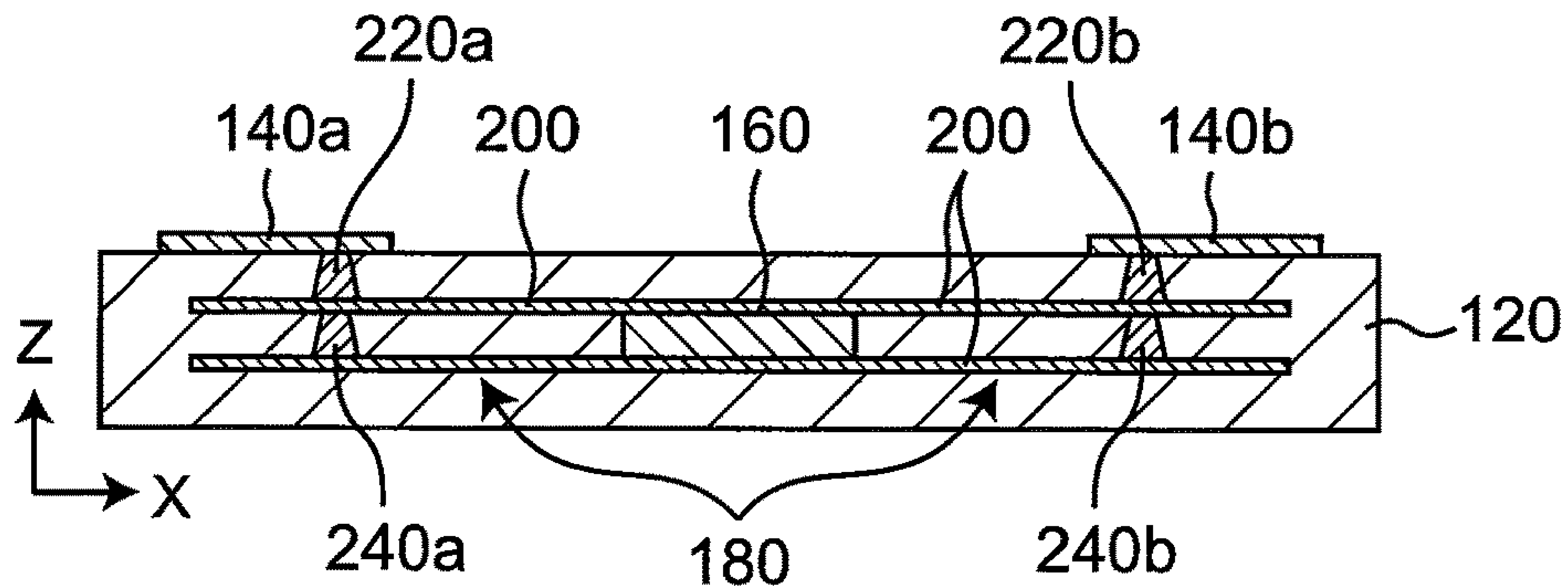


Fig.16A

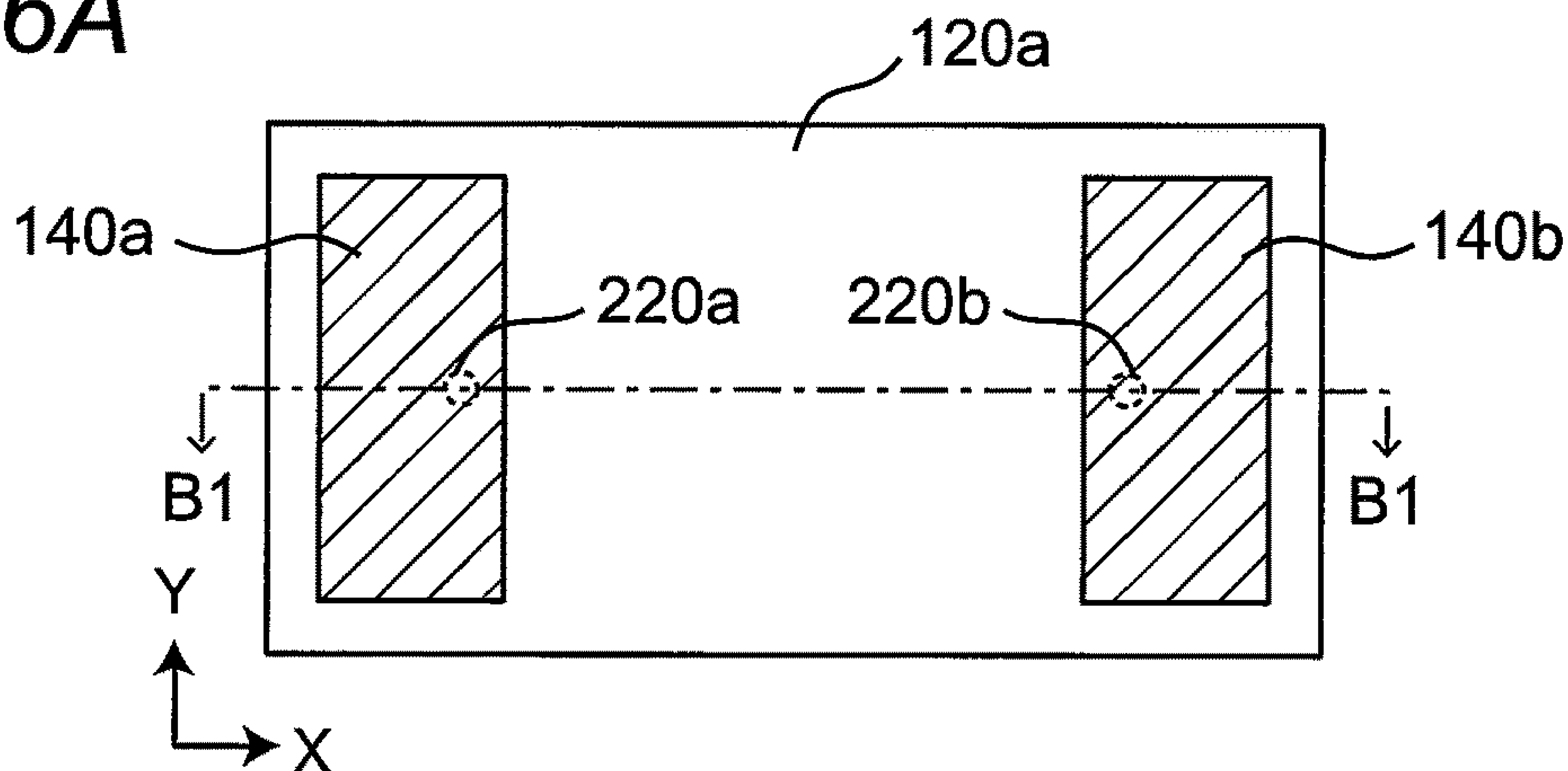


Fig. 16B

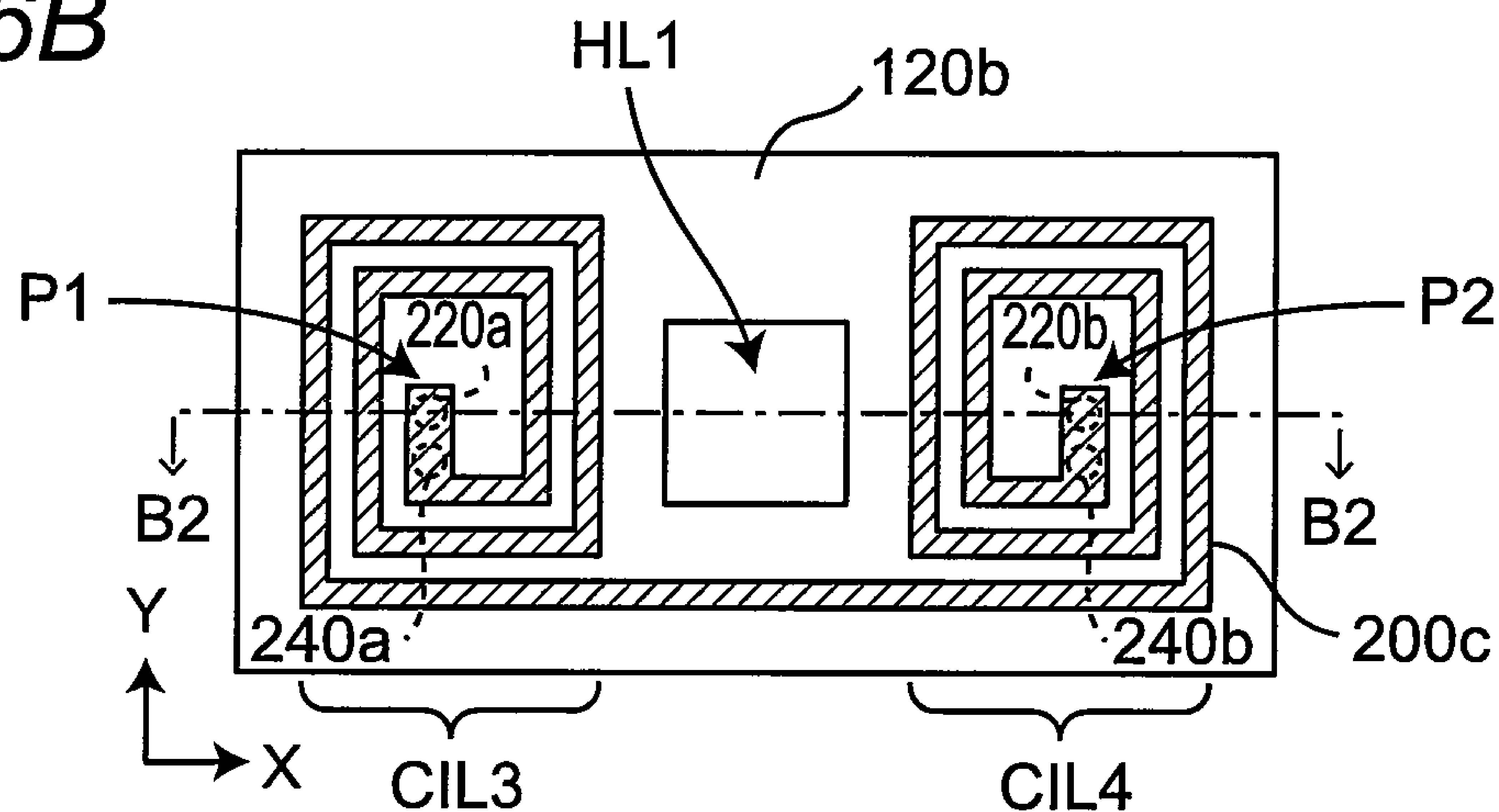


Fig. 16C

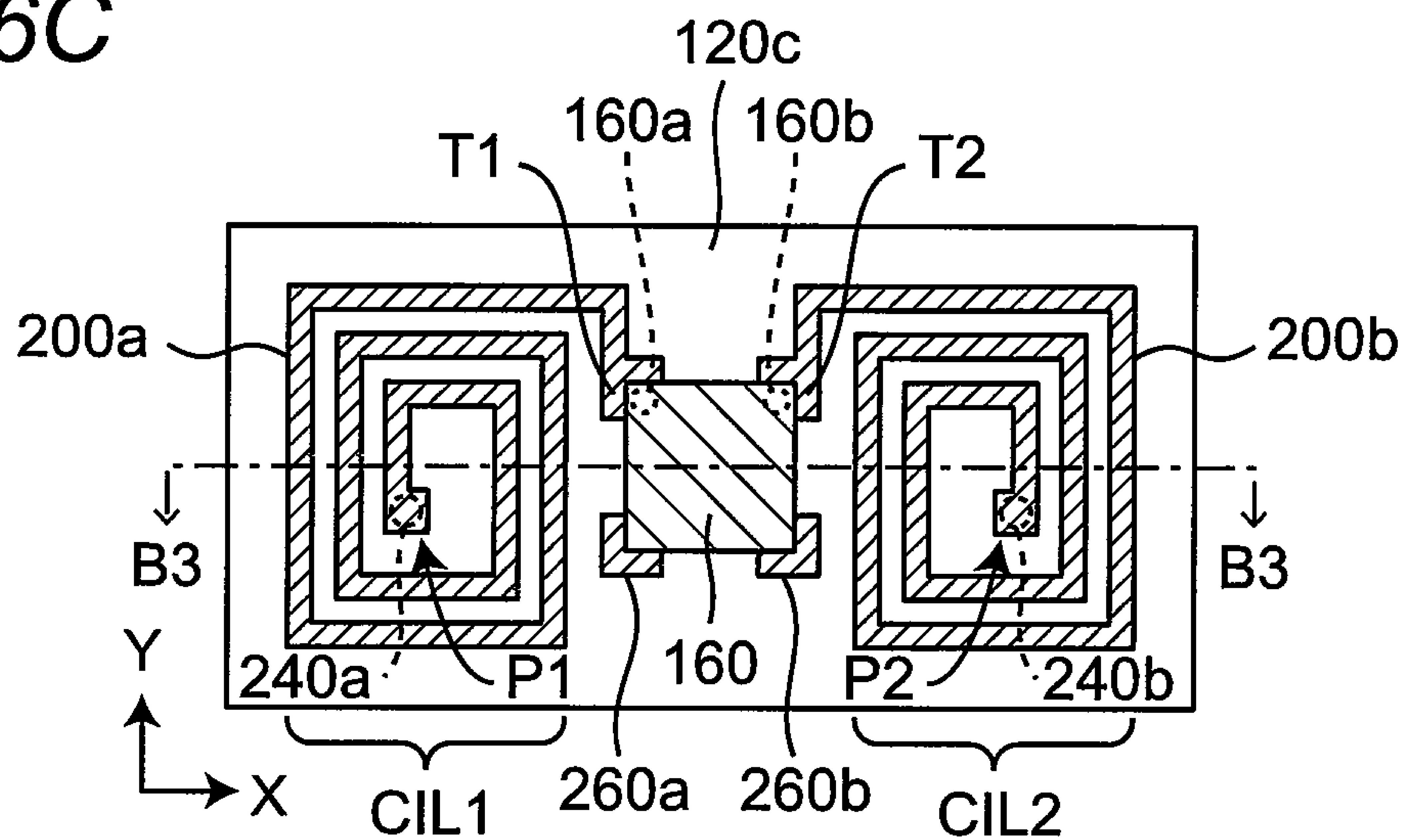


Fig. 17A

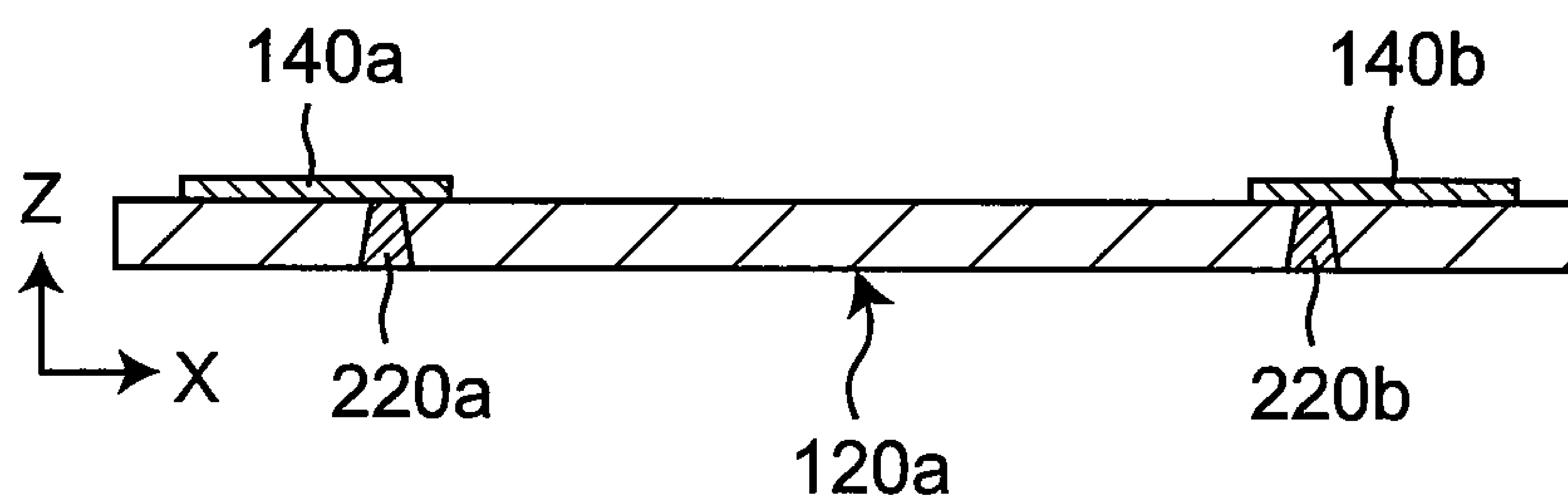


Fig. 17B

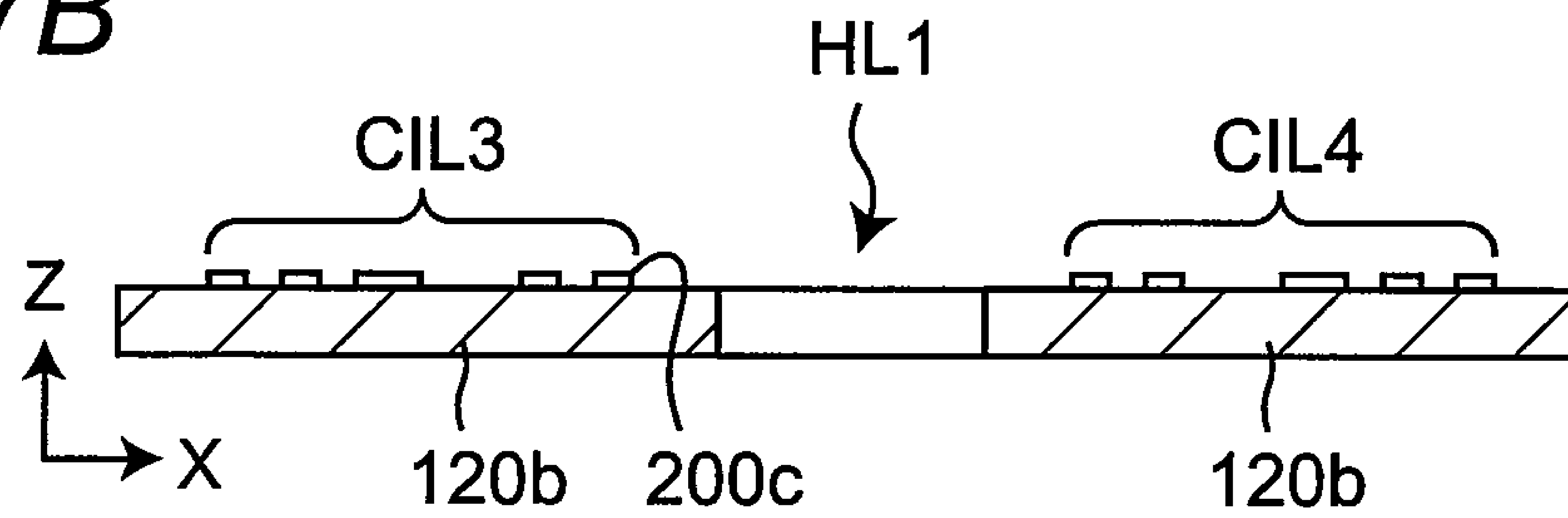


Fig. 17C

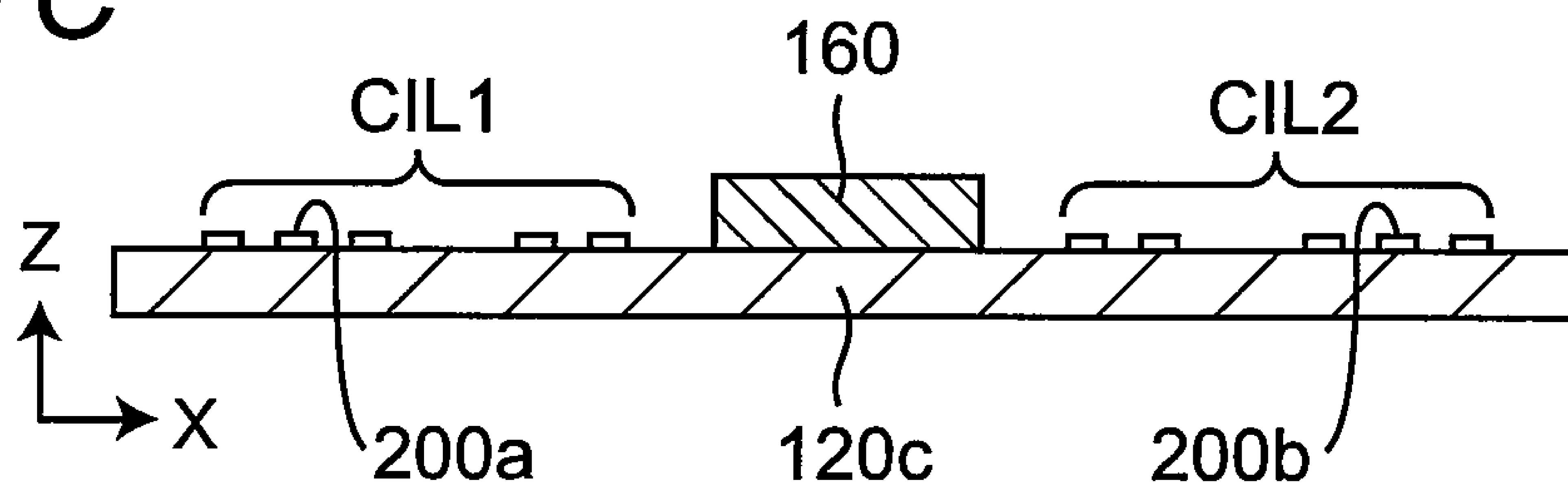


Fig. 18

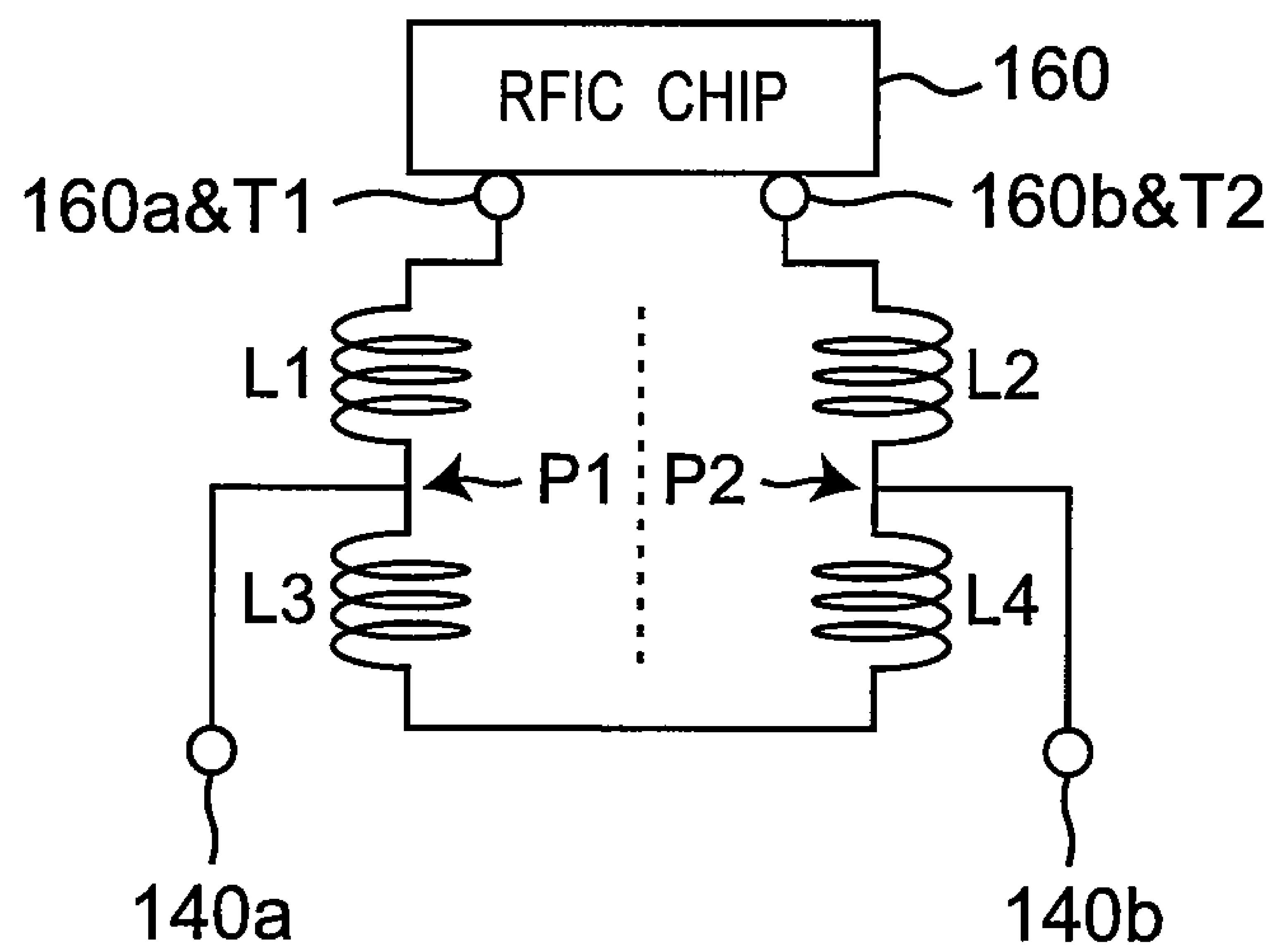


Fig.19

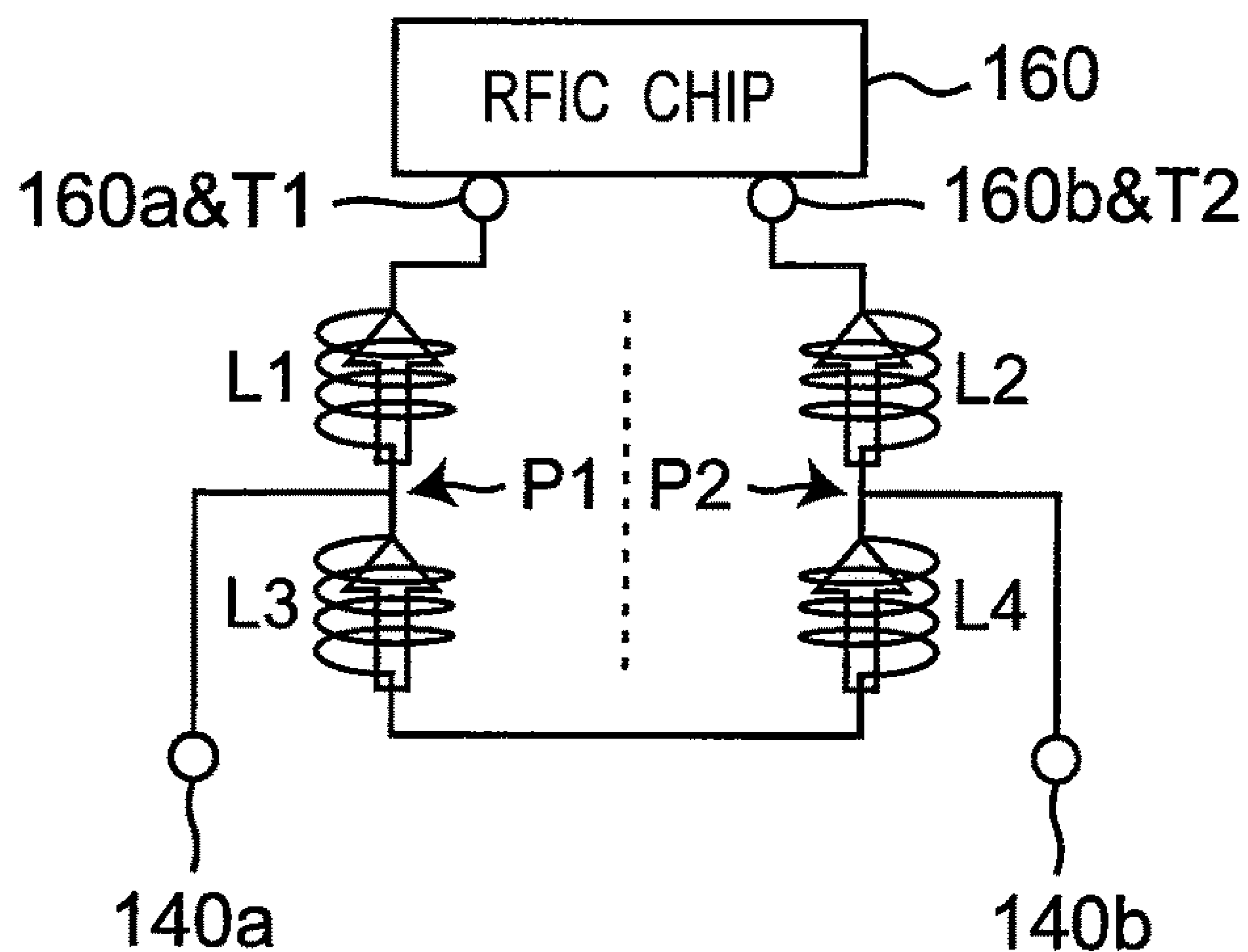


Fig.20

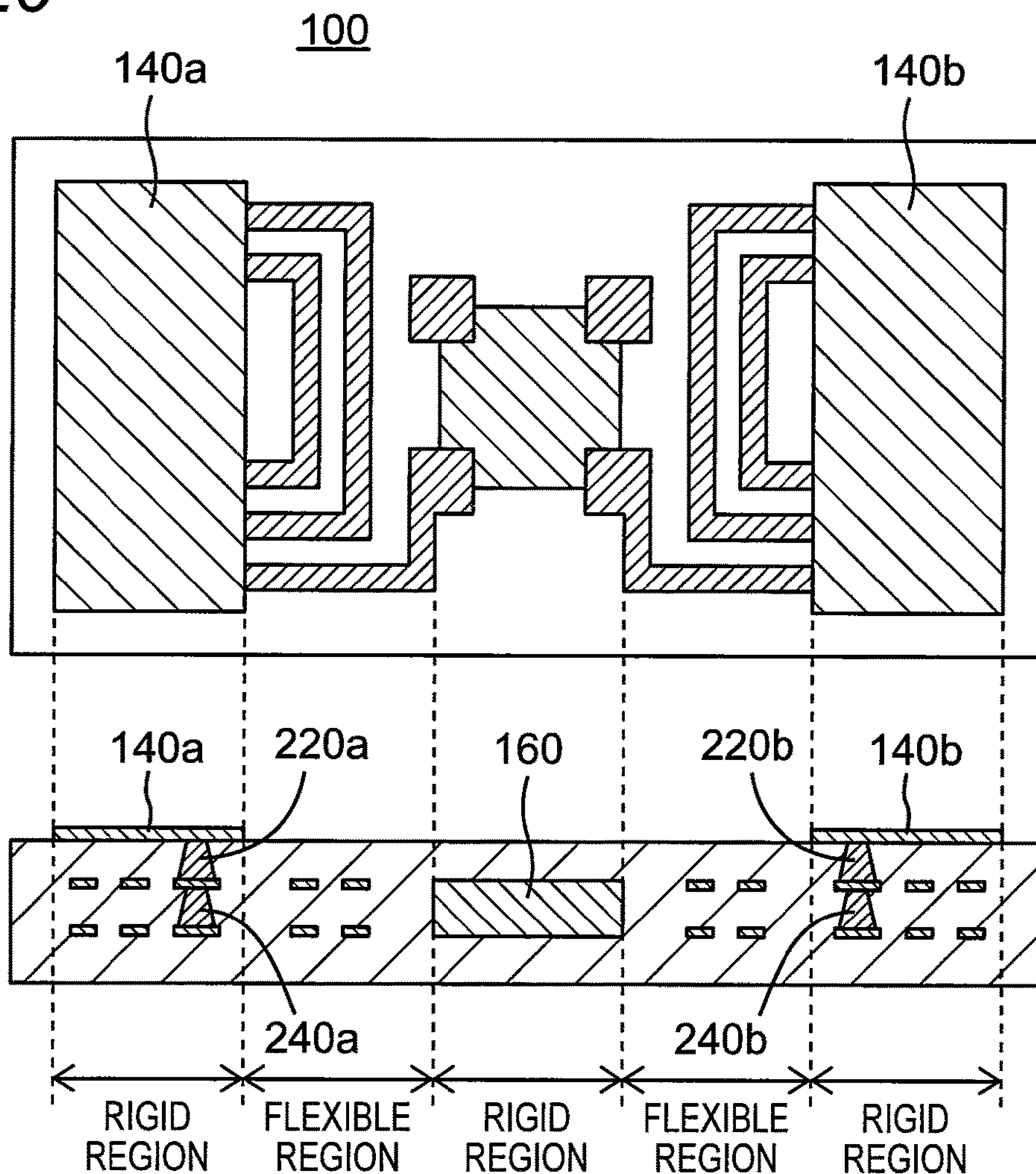


Fig.21

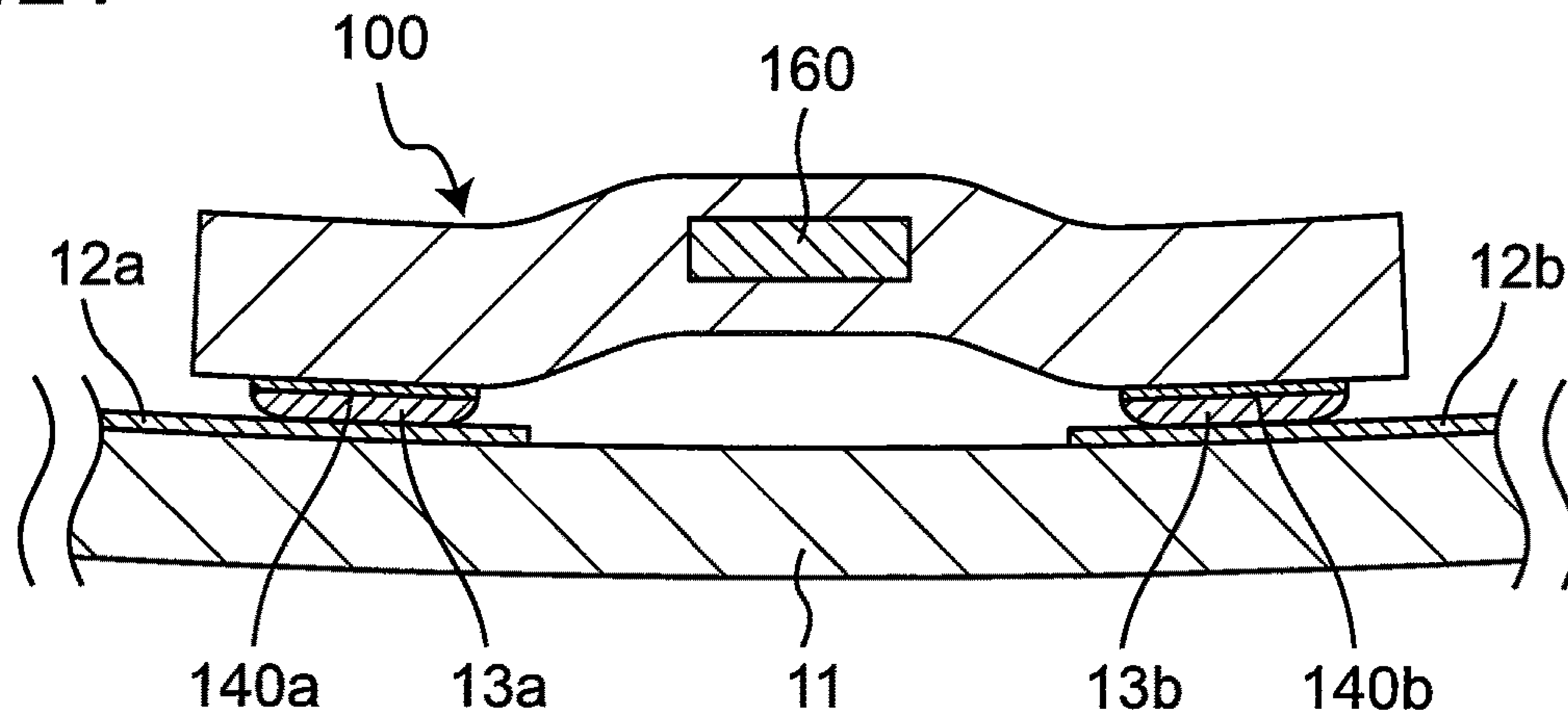


Fig.22

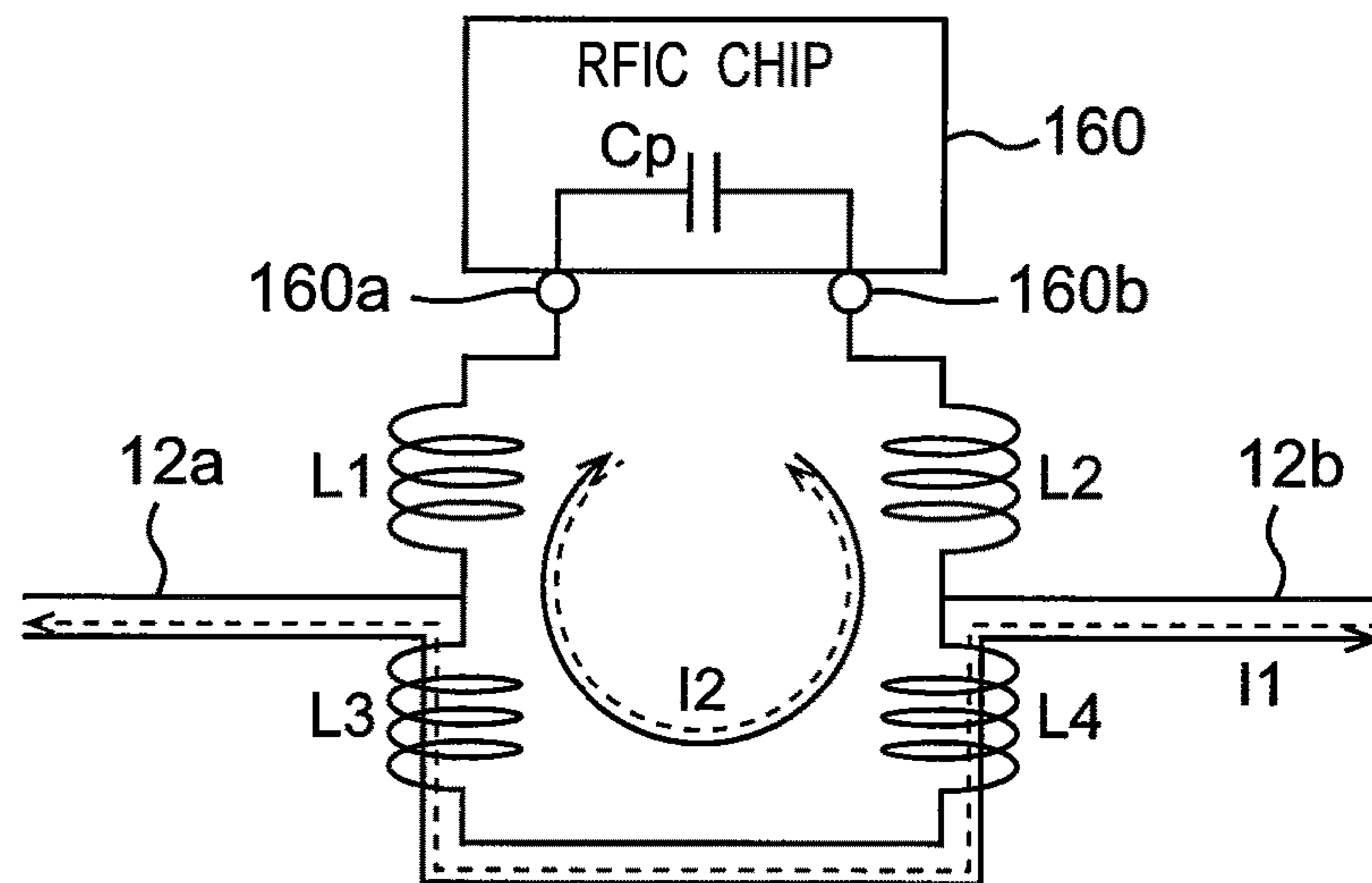


Fig. 23

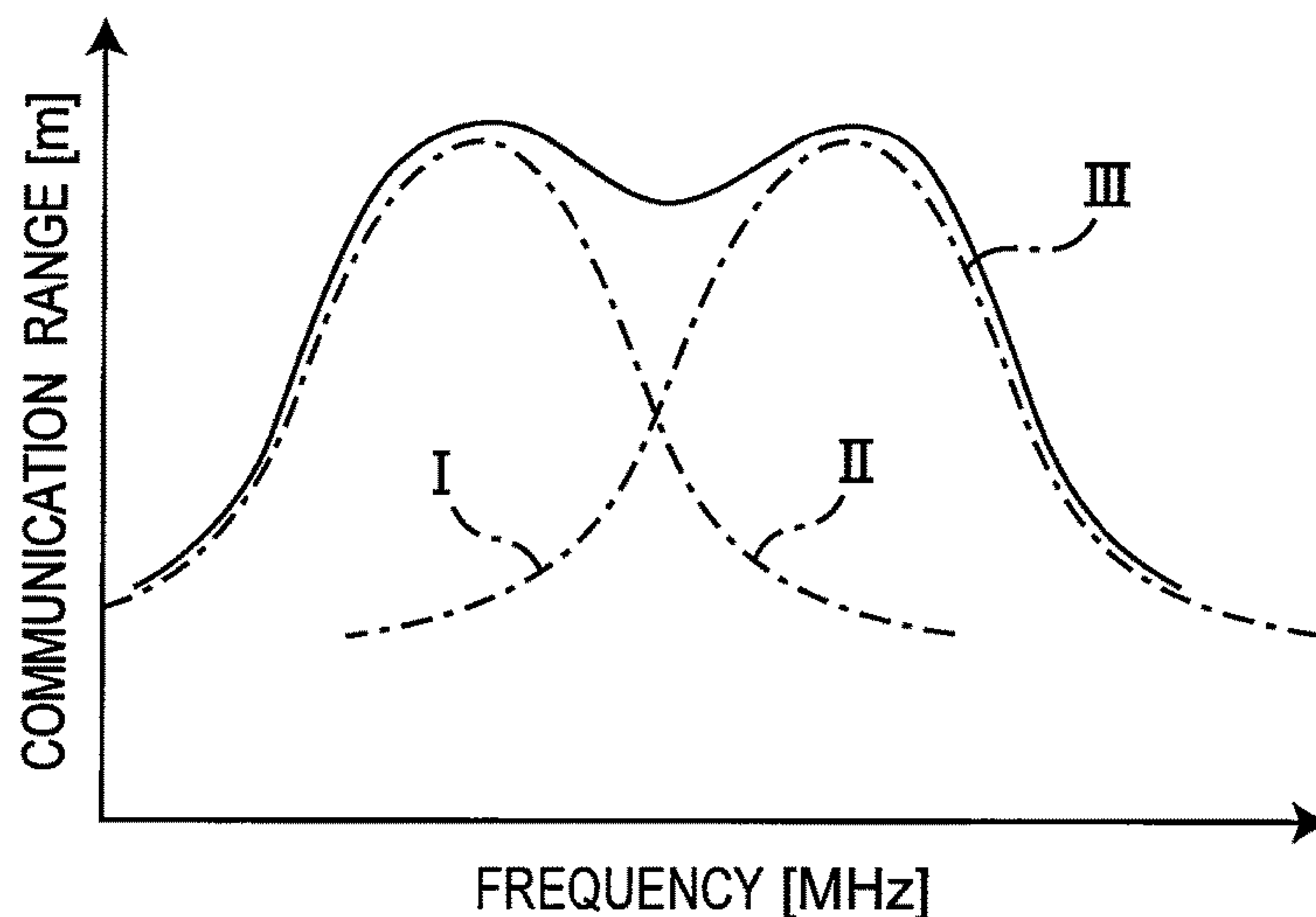


Fig. 24

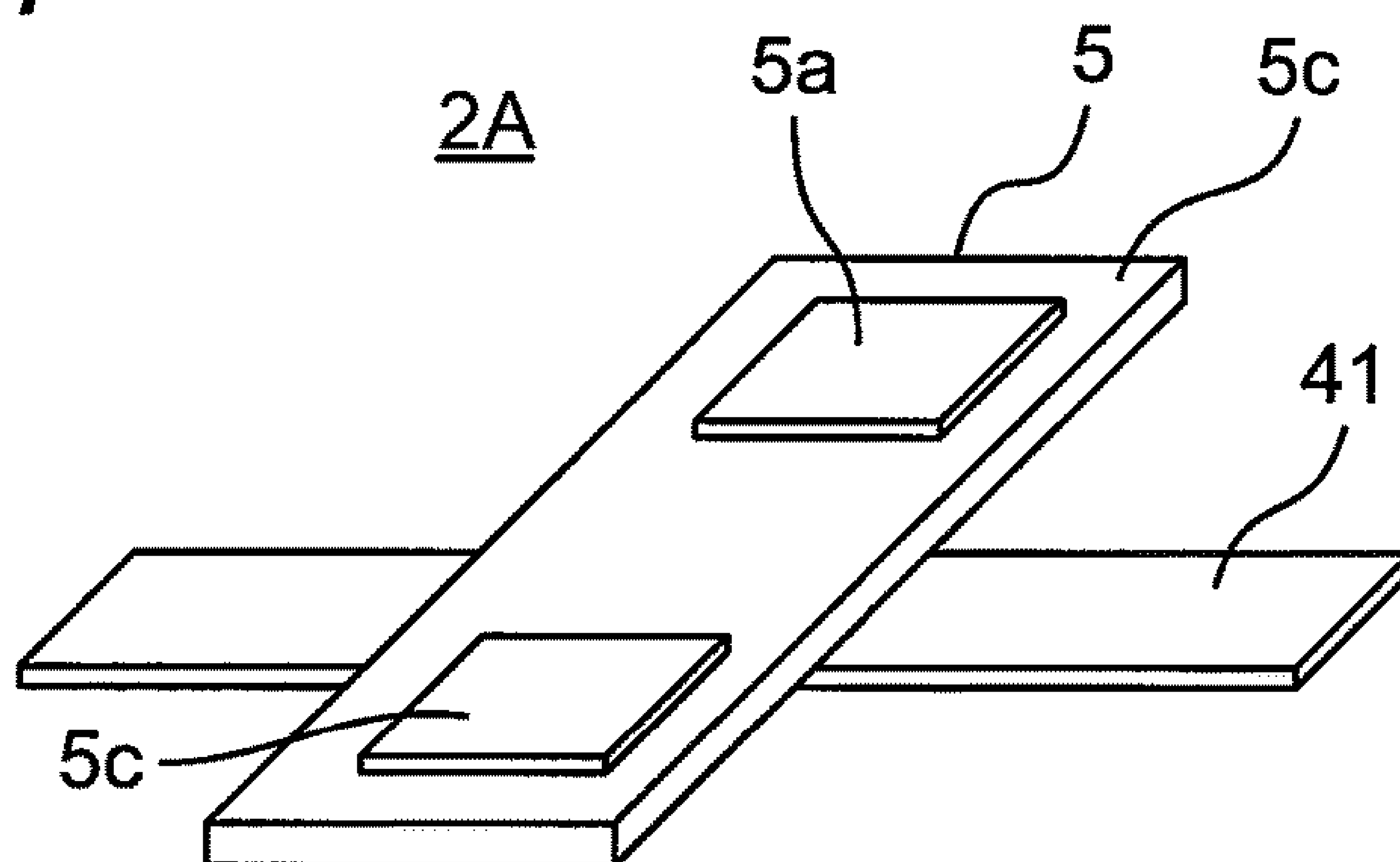


Fig. 25

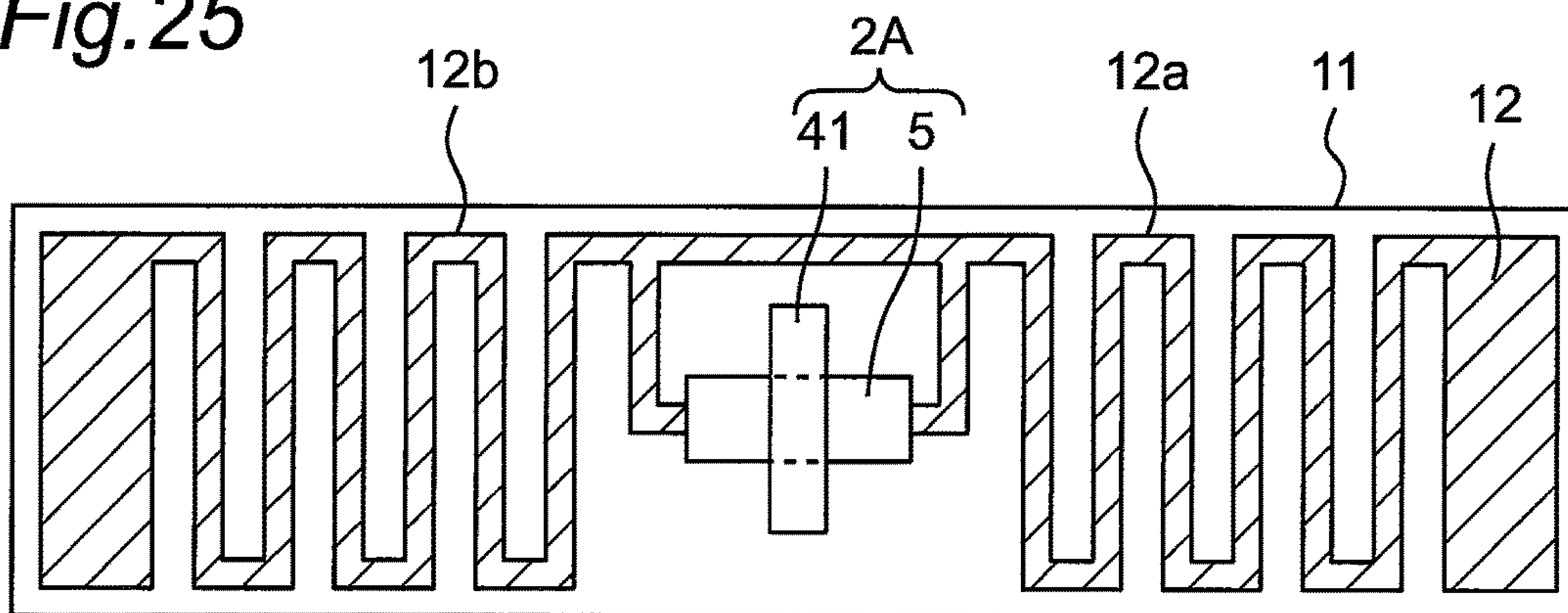


Fig.26

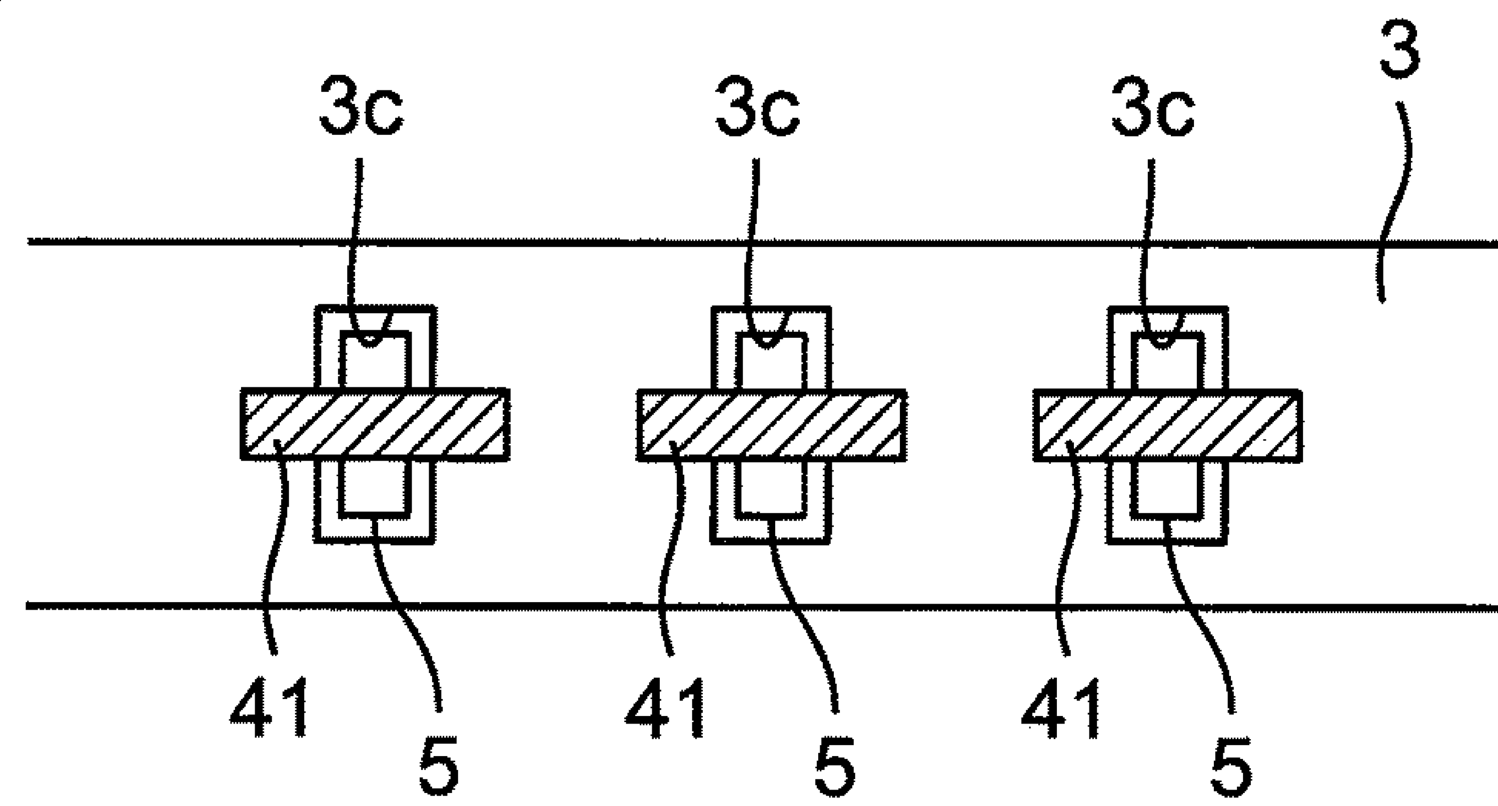


Fig.27

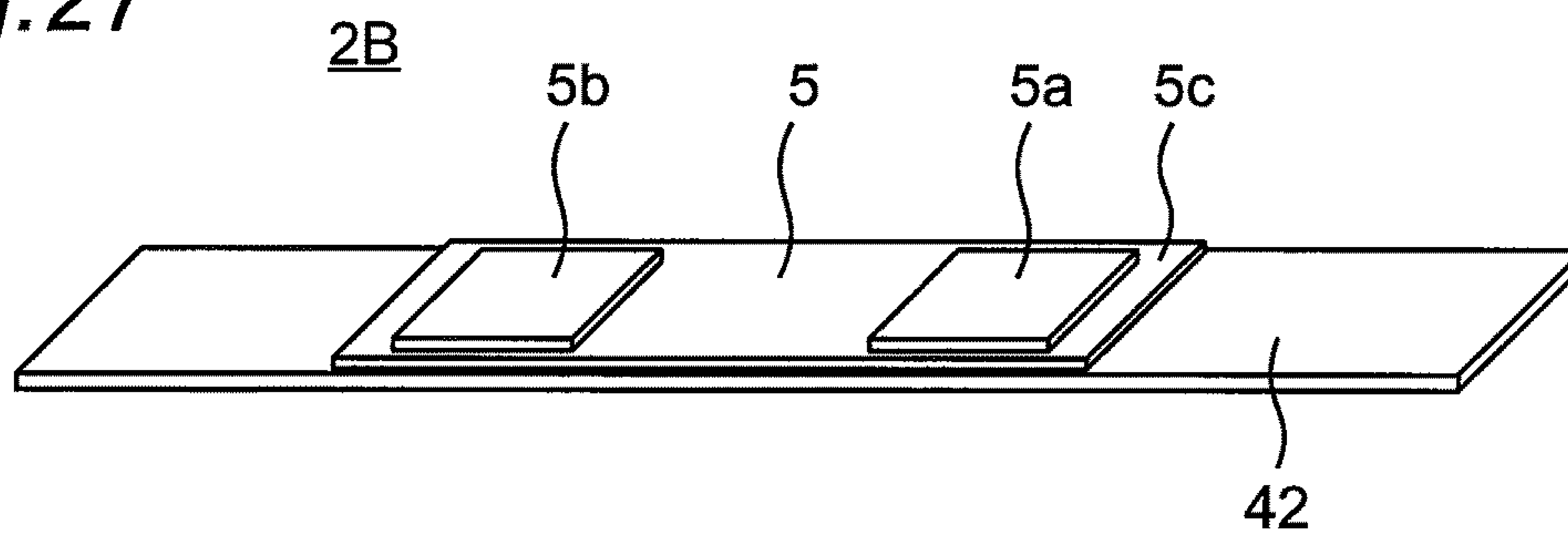


Fig.28

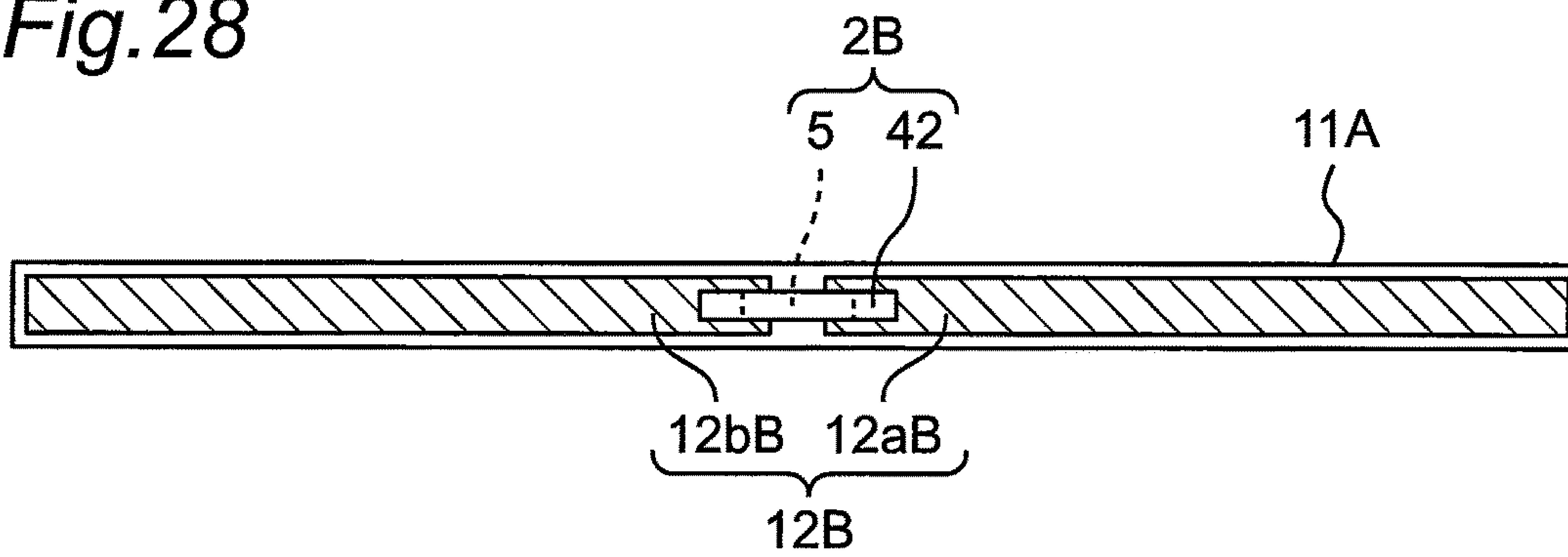
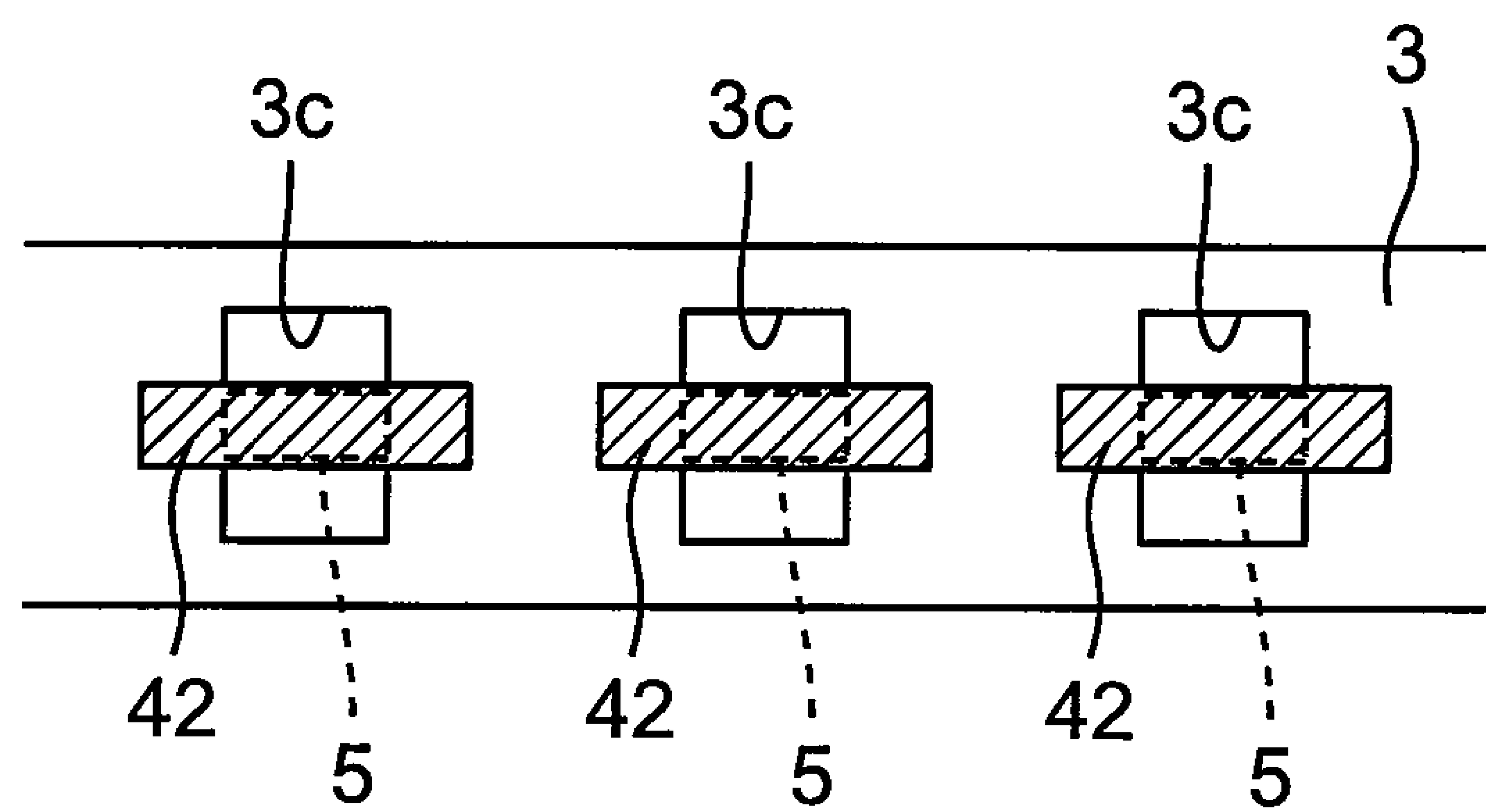


Fig.29



CARRIER TAPE, METHOD FOR MANUFACTURING SAME, AND METHOD FOR MANUFACTURING RFID TAG

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation application of international Application No. PCT/JP2015/080012, with an international filing date of Oct. 23, 2015, which claims priority of Japanese Patent Application No. 2014-227195 filed on Nov. 7, 2014, Japanese Patent Application No. 2014-239824 filed on Nov. 27, 2014, Japanese Patent Application No. 2015-030318 filed on Feb. 19, 2015, Japanese Patent Application No. 2015-044178 filed on Mar. 6, 2015, and Japanese Patent Application No. 2015-102092 filed on May 19, 2015, the entire contents of each of the applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for manufacturing an RFID (radio frequency identifier) tag as well as a carrier tape used for manufacturing the RFID tag and a method for manufacturing the same.

2. Description of the Related Art

For an article information management system, an RFID system is recently put to practical use and the RFID system allows a reader/writer and an RFID tag applied to an article to communicate in a noncontact technique utilizing a magnetic field or an electromagnetic field so as to transmit predetermined information.

The RFID tag is manufactured by attaching an RFIC element (an RFIC (radio frequency integrated circuit) chip itself or a package equipped with an RFIC chip) to an antenna base material provided with an antenna element. Conventionally known methods for connecting the RFIC element and the antenna element include methods for connection by heating and melting of solder, a conductive adhesive, etc. (see JP No. 2009-87068 A and JP No. 2009-129093 A) and methods for connection by ultrasonic bonding (see JP No. 2012-32931 A and JP No. 2013-45780 A). However, in the methods for connection by heating and melting of solder, a conductive adhesive, etc., a connection portion between the RFIC element and the antenna element must be heated to the melting point of solder, a conductive adhesive, etc. or higher. In this case, since the antenna base material is required to have high heat resistance, an inexpensive material such as polyethylene terephthalate (PET) cannot be used for the antenna base material. In the methods for connection by ultrasonic bonding, a bump must be melted ultrasonically. This case leads to problems such as a long time required for completing the ultrasonic bonding, and changes in quality and shape of polyethylene terephthalate (PET) that is the antenna base material at the temperature at which the bump melts. If a low-melting-point conductive adhesive is used, a bonding part is easily broken because of low bonding strength, resulting in degradation in electric characteristics and variations in characteristics.

If the antenna base material has flexibility, it is considered that the RFID tag can be affixed to a member having a curved surface or a member having flexibility. However, the conventional methods for connection as described above may cause a stress to concentrate on a connection portion between the RFID element and the antenna element and the connection portion may be destructed. Therefore, a new method is demanded for connecting an electronic component such as the RFIC element and a connection object such as the antenna element.

SUMMARY OF THE INVENTION

Preferred embodiments of the present invention to provide a carrier tape, a method for manufacturing the same, and a method for manufacturing an RFID tag capable of improving handleability of a component used in a new method for connecting an electronic component and a connection object.

A method for manufacturing a carrier tape according to a preferred embodiment of the present invention is a method for manufacturing a carrier tape housing a plurality of electronic components with seal materials, the method including the steps of forming a plurality of housing holes in a tape-shaped main body including a first principal surface and a second principal surface along a longitudinal direction of the tape-shaped main body, the housing holes penetrating from the first principal surface to the second principal surface; affixing an adhesive layer of a tape-shaped seal material to the second principal surface of the tape-shaped main body to cover the plurality of the housing holes; forming cuts in the tape-shaped seal material to separate portions defining and functioning as the seal materials including portions at least partially overlapping with the respective housing holes in a planar view from the other portions, and providing a chip-shaped electronic component into each of the plurality of the housing holes of the tape-shaped main body and fixing the electronic component to the adhesive layer of the seal material exposed in each of the housing holes.

A carrier tape according to a preferred embodiment of the present invention is a carrier tape housing a plurality of electronic components with seal materials, including a tape-shaped main body including a first principal surface and a second principal surface and including a plurality of housing holes penetrating from the first principal surface to the second principal surface along a longitudinal direction; a plurality of seal materials each including an adhesive layer on one principle surface and affixed to the second principal surface of the tape-shaped main body such that the adhesive layer is exposed in at least a portion of each of the housing holes; and a plurality of chip-shaped electronic components housed in the respective housing holes and fixed to the adhesive layers of the respective seal materials.

A method for manufacturing an RFID tag according to a preferred embodiment of the present invention includes the steps of preparing a carrier tape housing a plurality of RFIC elements with seal materials, the carrier tape including a tape-shaped main body including a first principal surface and a second principal surface and including a plurality of housing holes penetrating from the first principal surface to the second principal surface along a longitudinal direction, a plurality of seal materials each including an adhesive layer on one principle surface and affixed to the second principal surface of the tape-shaped main body such that the adhesive layer is exposed in at least a portion of each of the housing holes, and a plurality of RFIC elements housed in the respective housing holes and fixed to the adhesive layers of the respective seal materials; folding the tape-shaped main body to separate each of the RFIC elements with seal materials from the tape-shaped main body; and affixing the

separated RFIC element with a seal material to an antenna base material by the adhesive layer of the seal material.

Preferred embodiments of the present invention improve the handleability of a component used in a new method for connecting an electronic component and a connection object.

The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a general configuration of a carrier tape according to a first preferred embodiment of the present invention.

FIG. **2** is a cross-sectional view taken along a line A**1**-A**1** of FIG. **1**.

FIG. **3** is a perspective view of a general configuration of an electronic component with a seal material.

FIG. **4**A is a cross-sectional view of an example of a method for manufacturing the carrier tape of FIG. **1**.

FIG. **4**B is a cross-sectional view of a step continued from FIG. **4**A.

FIG. **4**C is a cross-sectional view of a step continued from FIG. **4**B.

FIG. **4**D is a cross-sectional view of a step continued from FIG. **4**C.

FIG. **4**E is a cross-sectional view of a step continued from FIG. **4**D.

FIG. **4**F is a cross-sectional view of a step continued from FIG. **4**E.

FIG. **4**G is a cross-sectional view of a step continued from FIG. **4**F.

FIG. **5** is a perspective view of a method for manufacturing an RFID tag.

FIG. **6** is a plane view of an antenna element and an antenna base material.

FIG. **7** is a cross-sectional view taken along a line A**2**-A**2** of FIG. **6**.

FIG. **8** is a plane view of a state in which the electronic component with a seal material is attached onto the antenna element.

FIG. **9** is a cross-sectional view taken along a line A**3**-A**3** of FIG. **8**.

FIG. **10** is a side view of an example of a method for manufacturing a plurality of RFID tags by using the carrier tape of FIG. **1**.

FIG. **11** is an enlarged cross-sectional view of a portion surrounded by a dotted line of FIG. **10**.

FIG. **12** is a side view of another example of the method for manufacturing a plurality of RFID tags by using the carrier tape of FIG. **1**.

FIG. **13** is an enlarged cross-sectional view of a portion surrounded by a dotted line of FIG. **12**.

FIG. **14** is a perspective view of an RFIC element that is an example of an electronic component.

FIG. **15** is a transverse cross-sectional view of the RFIC element shown in FIG. **14**.

FIG. **16**A is a plane view of an upper insulation layer of a multilayer substrate making up the RFIC element shown in FIG. **14** viewed from directly above.

FIG. **16**B is a plane view of an intermediate insulation layer of the multilayer substrate making up the RFIC element shown in FIG. **14** viewed from directly above.

FIG. **16**C is a plane view of a lower insulation layer of the multilayer substrate making up the RFIC element shown in FIG. **14** viewed from directly above.

FIG. **17**A is a cross-sectional view of the insulation layer shown in FIG. **16**A taken along a line B**1**-B**1**.

FIG. **17**B is a cross-sectional view of the insulation layer shown in FIG. **16**B taken along a line B**2**-B**2**.

FIG. **17**C is a cross-sectional view of the insulation layer shown in FIG. **16**C taken along a line B**3**-B**3**.

FIG. **18** is a diagram of an equivalent circuit of the RFIC element shown in FIG. **14**.

FIG. **19** is a diagram of an example of a state of a magnetic field occurring on the equivalent circuit shown in FIG. **18**.

FIG. **20** is a diagram of distribution of rigid and flexible regions in the RFIC element shown in FIG. **14**.

FIG. **21** is a diagram of a bent state of an RFID tag having the RFIC element shown in FIG. **14** attached to an antenna element.

FIG. **22** is a diagram of an example in which a current flows through an equivalent circuit of the RFID tag of FIG. **21**.

FIG. **23** is a graph of an example of resonance frequency characteristics of the RFID tag of FIG. **21**.

FIG. **24** is a perspective view of a general configuration of an electronic component with a seal material according to a second preferred embodiment of the present invention.

FIG. **25** is a plane view of a state of the electronic component with a seal material of FIG. **24** attached to an antenna element of an antenna base material.

FIG. **26** is a bottom view of a state of the electronic component with a seal material of FIG. **24** in which the portions other than those defining and functioning as the seal materials are separated from a tape-shaped main body.

FIG. **27** is a perspective view of a general configuration of an electronic component with a seal material according to a third preferred embodiment of the present invention.

FIG. **28** is a plane view of a state of the electronic component with a seal material of FIG. **27** attached to an antenna element of an antenna base material.

FIG. **29** is a bottom view of a state of the electronic component with a seal material of FIG. **27** in which the portions other than those defining and functioning as the seal member are separated from the tape-shaped main body.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As described above, a new method for connection is demanded for connecting an electronic component such as an RFIC element and a connection object such as an antenna element. Therefore, the present applicant is making progress in development of an electronic component with a seal material acquired by affixing the electronic component to an adhesive layer on one principal surface of the seal member. This electronic component with a seal material is used in such a manner that the seal member is affixed by the adhesive layer to the connection object so as to bring a terminal electrode on the electronic component into contact with the connection object.

In this case, the terminal electrode of the electronic component is able to be brought into contact with the connection object to retain electric contact between the terminal electrode of the electronic component and the connection object. Additionally, the connection between the electronic component and the connection object is able to be maintained by affixing the seal member to the connection

object, and this eliminates the need for direct fixation using ultrasonic etc. or fixation using a bonding material between the terminal electrode of the electronic component and the connection object.

Therefore, even when the connection object is bent, a stress is prevented from concentrating on a connection portion between the electronic component and the connection object, and the connection portion is prevented from being destructed.

As a result of intensive studies for improving the handleability of the electronic component with a seal that is a component used in the new method for connection described above, the following preferred embodiments of the present invention were conceived by the present applicant.

A method for manufacturing a carrier tape according to a preferred embodiment of the present invention is a method for manufacturing a carrier tape housing a plurality of electronic components with seal materials, the method including the steps of forming a plurality of housing holes in a tape-shaped main body including a first principal surface and a second principal surface along a longitudinal direction of the tape-shaped main body, the housing holes penetrating from the first principal surface to the second principal surface; affixing an adhesive layer of a tape-shaped seal material to the second principal surface of the tape-shaped main body to cover the plurality of the housing holes; forming cuts in the tape-shaped seal material to separate portions defining and functioning as the seal materials including portions at least partially overlapping with the respective housing holes in a planar view from the other portions, and providing a chip-shaped electronic component into each of the plurality of the housing holes of the tape-shaped main body and fixing the electronic component to the adhesive layer of the seal material exposed in each of the housing holes.

According to this method for manufacturing, the plurality of the electronic components with seal materials is housed in the carrier tape and, therefore, the handleability of the plurality of the electronic components with seal materials is improved. Additionally, since the seal materials necessary for manufacturing RFID tags are affixed to the second principal surface of the tape-shaped main body to retain the electronic components, it is not necessary to dispose another member unnecessary for manufacturing RFID tags to retain the electronic components in the housing holes. Therefore, manufacturing steps are shortened and manufacturing costs are reduced.

A method for manufacturing a carrier tape may further include a step of affixing a tape-shaped cover material to the first principal surface of the tape-shaped main body to cover the plurality of the housing holes housing the electronic components.

According to this method for manufacturing, dusts etc. are prevented from entering the housing holes housing the electronic components, and the handleability of the electronic components with seal materials is further improved.

A method for manufacturing a carrier tape may further include a step of separating the portions other than those defining and functioning as the seal materials from the tape-shaped main body after the cuts are formed in the tape-shaped seal material.

According to this method for manufacturing, when the electronic components with seal materials are separated from the tape-shaped main body, the electronic components with seal materials are separated after the portions other than those defining and functioning as the seal materials are removed, and therefore is easily removed.

The electronic component may have a terminal electrode on a surface on the side opposite to a fixation surface fixed to the adhesive layer of the seal material.

A carrier tape according to a preferred embodiment of the present invention is a carrier tape housing a plurality of electronic components with seal materials, the carrier tape including a tape-shaped main body including a first principal surface and a second principal surface and including a plurality of housing holes penetrating from the first principal surface to the second principal surface along a longitudinal direction; a plurality of seal materials each including an adhesive layer on one principle surface and affixed to the second principal surface of the tape-shaped main body such that the adhesive layer is exposed in at least a portion of each of the housing holes; and a plurality of chip-shaped electronic components housed in the respective housing holes and fixed to the adhesive layers of the respective seal materials.

According to this carrier tape, the plurality of the electronic components with seal materials is housed in the carrier tape and, therefore, the handleability of the plurality of the electronic components with seal materials is improved. Additionally, since the seal materials necessary for manufacturing RFID tags are affixed to the second principal surface of the tape-shaped main body to retain the electronic components, it is not necessary to dispose another member unnecessary for manufacturing RFID tags for retaining the electronic components in the housing holes. Therefore, manufacturing steps are shortened and manufacturing costs are reduced.

Preferably, the seal materials have rigidity higher than the tape-shaped main body. As a result, when the tape-shaped main body is folded, the separation of the seal materials from the tape-shaped main body is facilitated.

The electronic components may be components that define RFID tags and may each include an RFIC chip and a substrate equipped with the RFIC chip.

The substrate may be a substrate that defines a RFID tag and may include a power feeding circuit for impedance matching between an antenna element and the RFIC chip.

A method for manufacturing an RFID tag according to a preferred embodiment of the present invention includes the steps of preparing a carrier tape housing a plurality of RFIC elements with seal materials, the carrier tape including a tape-shaped main body including a first principal surface and a second principal surface and including a plurality of housing holes penetrating from the first principal surface to the second principal surface along a longitudinal direction, a plurality of seal materials each having an adhesive layer on one principle surface and affixed to the second principal surface of the tape-shaped main body such that the adhesive layer is exposed in at least a portion of each of the housing holes, and a plurality of RFIC elements housed in the respective housing holes and fixed to the adhesive layers of the respective seal materials; folding the tape-shaped main body to separate each of the RFIC elements with seal materials from the tape-shaped main body; and affixing the separated RFIC element with a seal material to an antenna base material by the adhesive layer of the seal material.

According to this method for manufacturing, the RFIC elements with seal materials are the plurality of the electronic components and are housed in the carrier tape and, therefore, the handleability of the plurality of the RFIC elements with seal materials is improved. Additionally, since the seal materials necessary for manufacturing the RFID tags are affixed to the second principal surface of the tape-shaped main body to retain the RFIC elements, it is not

necessary to dispose another member unnecessary for manufacturing the RFID tags to retain the RFIC elements in the housing holes. Moreover, since the electronic components with seal materials are separated from the tape-shaped main body by simply folding the tape-shaped main body, manufacturing steps are shortened and manufacturing costs are reduced.

The carrier tape may be wound around a supply reel, and while the carrier tape is continuously pulled out from the supply reel, the tape-shaped main body of the pulled-out carrier tape may be folded at a certain position away from the supply reel to sequentially separate the plurality of the RFIC elements with seal materials from the tape-shaped main body.

According to this method for manufacturing, for example, the plurality of the RFIC elements are able to be separated from the tape-shaped main body at high speed. Consequently, a plurality of RFID tags are able to be manufactured in shorter time.

Preferably, the seal materials have a shape (e.g., a rectangular or substantially rectangular shape) having a longitudinal direction and a transverse direction in a planar view and, when each of the RFIC elements with seal materials is separated from the tape-shaped main body, a portion in the longitudinal direction of the seal material is first separated. As a result, the RFIC elements with seal materials are more easily be separated from the tape-shaped main body.

Preferred embodiments of the present invention will now be described with reference to the drawings.

First Preferred Embodiment

FIG. **1** is a plan view of a general configuration of a carrier tape according to a first preferred embodiment of the present invention. FIG. **2** is a cross-sectional view taken along a line **A1**-**A1** of FIG. **1**. FIG. **3** is a perspective view of a general configuration of an electronic component with a seal material.

As shown in FIGS. **1** and **2**, a carrier tape **1** according to the first preferred embodiment is configured to house a plurality of electronic components **2** with seal materials. More specifically, the carrier tape **1** includes a tape-shaped main body **3**, a plurality of seal materials **4**, a plurality of chip-shaped electronic components **5**, and a tape-shaped cover material **6**. The electronic components **2** with seal materials include the seal materials **4** and the electronic components **5**.

The tape-shaped main body **3** includes a first principal surface **3***a* and a second principal surface **3***b*. The first principal surface **3***a* and the second principal surface **3***b* are subjected to a release treatment. The tape-shaped main body **3** is provided with a plurality of housing holes **3***c* penetrating from the first principal surface **3***a* to the second principal surface **3***b*. The plurality of the housing holes **3***c* is arranged in the longitudinal direction of the tape-shaped main body **3**. The arrangement intervals of the housing holes **3***c* are equal or substantially equal intervals, for example. The housing holes **3***c* have a size slightly larger than the electronic components **5** so that the electronic components **5** are entirely housed in a planar view while a gap of about 0.1 mm to about 2 mm, for example, is formed around the electronic components **5**. The "planar view" as used herein refers to a state viewed in the direction shown in FIG. **1**. The tape-shaped main body **3** includes a member having flexibility such as polyethylene terephthalate (PET) and paper, for example. The thickness of the tape-shaped main body **3** is about 50 μm to about 800 μm, for example. The thickness of the tape-shaped main body **3**, i.e., the depth of the housing holes **3***c*, is the same or substantially the same as the thickness of the electronic components **5** or thinner than the thickness of the electronic components **5**.

The seal materials **4** are affixed to, for example, an antenna base material **11** described later to retain an electrical connection between an antenna element **12** that is an example of a connection object, and the electronic component **5**. Each of the seal materials **4** includes an adhesive layer **4***a* on one principal surface. The adhesive layer **4***a* is provided on the one entire principal surface of the seal material **4**, for example. The seal materials **4** are affixed to the second principal surface **3***b* of the tape-shaped main body **3** such that the adhesive layers **4***a* are exposed in the housing holes **3***c*. In the first preferred embodiment, the seal materials **4** preferably have a size larger than the housing holes **3***c* so as to completely cover the housing holes **3***c*. The seal material **4** include members having flexibility and elasticity such as polyethylene, polypropylene, polyvinyl butyral (PVB), and paper, for example. The thickness of the seal materials **4** is about 20 μm to about 200 μm, for example.

The electronic components **5** are housed in the housing holes **3***c* and fixed to the adhesive layers **4***a* of the seal materials **4**. In the first preferred embodiment, the electronic components **5** are RFIC elements (packages or straps with RFIC chips sealed therein), for example. The RFIC elements are ultrathin packages, for example. As shown in FIG. **3**, each of the electronic components **5** includes a first terminal electrode **5***a* and a second terminal electrode **5***b* on a surface on the side opposite to a fixation surface fixed to the adhesive layer **4***a* of the seal material **4**. The first terminal electrode **5***a* and the second terminal electrode **5***b* are provided on a substrate **5***c* including an RFIC chip. The substrate **5***c* is made of a flexible material such as a liquid crystal polymer resin or a polyimide resin. The height (thickness) of the electronic component **5** is about 50 μm to about 1 mm, for example.

The tape-shaped cover material **6** is affixed to the first principal surface **3***a* of the tape-shaped main body **3** to cover the plurality of the housing holes **3***c* housing the electronic components **5**. One surface of the tape-shaped cover material **6** has weak adhesiveness so as to facilitate separation even when the electronic components **5** housed in the housing holes **3***c* are affixed thereto. The tape-shaped cover material **6** has a width shorter than the tape-shaped main body **3** and is affixed to the tape-shaped main body **3** such that the first principal surface **3***a* of the tape-shaped main body **3** is exposed at both end portions in the width direction. The both end portions in the width direction of the tape-shaped main body **3** is provided with a plurality of feed holes **3***d* along the longitudinal direction of the tape-shaped main body **3**. The tape-shaped cover material **6** is preferably made of a flexible material such as polystyrene, for example. The thickness of the tape-shaped cover material **6** is about 50 μm to about 200 μm, for example.

According to the carrier tape according to the first preferred embodiment, the plurality of the electronic components **2** with seal materials is housed in the carrier tape **1** and, therefore, the handleability of the plurality of the electronic components **2** with seal materials is improved. Additionally, since the seal materials **4** necessary for manufacturing RFID tags are affixed to the second principal surface **3***b* of the tape-shaped main body **3** to retain the electronic components **5**, it is not necessary to dispose another member unnecessary for manufacturing RFID tags to retain the electronic com-

ponents **5** in the housing holes **3***c*. Therefore, manufacturing steps are shortened and manufacturing costs are reduced.

Although the electronic components **5** preferably are RFIC elements in the first preferred embodiment, this is not a limitation of the present invention. If the electronic components **2** with seal materials are used for a purpose other than manufacturing of RFID tags, the electronic components **5** may be components other than the RFIC elements. For example, the electronic components **5** may be temperature sensors, acceleration sensors, etc. In this case, a plurality of sensor components with seal materials may be housed in a carrier tape, and the carrier tape may be used to affix the sensor components with seal materials to articles that are an example of the connection object such as a carrying case. As a result, the plurality of the sensor components are able to be mounted on articles at high speed.

Although the adhesive layer **4***a* is provided on the one entire principal surface of the seal material **4**, this is not a limitation of the present invention. The adhesive layer **4***a* may be dispersedly disposed at necessary positions on the one principal surface of the seal material **4**.

A method for manufacturing a carrier tape according to the first preferred embodiment will be described. FIGS. **4**A to **4**G are a cross-sectional views of an example of the method for manufacturing a carrier tape according to the first preferred embodiment.

First, as shown in FIG. **4**A, the belt-shaped tape-shaped main body **3** is prepared.

As shown in FIG. **4**B, the plurality of the housing holes **3***c* penetrating from the first principal surface **3***a* to the second principal surface **3***b* are arranged along the longitudinal direction of the tape-shaped main body **3**.

As shown in FIG. **4**C, the adhesive layer **4***a* of a tape-shaped seal material **4**A also being belt-shaped and made of the same material as the seal materials **4** is affixed to the second principal surface **3***b* of the tape-shaped main body **3** so as to cover the plurality of the housing holes **3***c*.

As shown in FIG. **4**D, cuts **4***c* are formed in the tape-shaped seal material **4**A such that portions defining and functioning as the seal materials **4** including portions overlapping with the housing holes **3***c* in the planar view are separated from other portions **4***b*. In this case, the cuts reach the second principal surface **3***b* of the tape-shaped main body **3**.

As shown in FIG. **4**E, the other portions **4***b* are separated from the tape-shaped main body **3**. The other portions **4***b* are connected in the longitudinal direction of the tape-shaped seal material **4**A and therefore are able to be sequentially peeled off from the tape-shaped main body **3**.

As shown in FIG. **4**F, the electronic components **5** are housed in the plurality of the respective housing holes **3***c* of the tape-shaped main body **3** and the electronic components **5** are fixed to the adhesive layers **4***a* of the seal materials **4** exposed in the housing holes **3***c*.

The tape-shaped cover material **6** is affixed to the first principal surface **3***a* of the tape-shaped main body **3** to cover the plurality of the housing holes **3***c* housing the electronic components **5**. The seal materials **4** and the tape-shaped cover material **6** have flexibility, and the thickness of the electronic components **5** is the same or substantially the same as or greater than the depth of the housing holes **3***c*. Therefore, a pressure is applied to connection surfaces between the electronic components **5** and the seal materials **4** at a step of affixing the tape-shaped cover material **6**, so that the electronic components **5** and the seal materials **4** are strongly bonded.

According to the method for manufacturing a carrier tape according to the first preferred embodiment, the plurality of the electronic components **2** with seal materials is housed in the carrier tape **1** and, therefore, the handleability of the plurality of the electronic components **2** with seal materials is improved. Particularly, rather than housing the electronic components **2** with seal materials into the carrier tape **1**, the seal materials **4** are affixed in advance to the carrier tape **1**, and the electronic components **5** are retained by the seal materials **4** at the step of housing the electronic components **5** into the housing holes **3***c*. Therefore, the electronic components **2** with seal materials are significantly improved in manufacturing efficiency and reliability. Additionally, since the seal materials **4** necessary for manufacturing RFID tags are affixed to the second principal surface **3***b* of the tape-shaped main body **3** to retain the electronic components **5**, it is not necessary to dispose another member unnecessary for manufacturing RFID tags to retain the electronic components **5** in the housing holes **3***c*. Therefore, manufacturing steps are shortened and manufacturing costs are reduced.

According to the method for manufacturing a carrier tape according to the first preferred embodiment, the tape-shaped cover material **6** is affixed to the first principal surface **3***a* of the tape-shaped main body **3**. Therefore, dusts etc. are prevented from entering the housing holes **3***c* housing the electronic components **5**, and the handleability of the electronic components **2** with seal materials is further improved.

According to the method for manufacturing a carrier tape according to the first preferred embodiment, the cuts **4***c* are formed in the tape-shaped seal material **4**A before separating the portions **4***b* other than those defining and functioning as the seal materials **4** from the tape-shaped main body **3**. As a result, when the electronic components **2** with seal materials are separated from the tape-shaped main body **3**, the electronic components **2** with seal material are separated after the portions **4***b* other than those defining and functioning as the seal materials **4** are removed, and therefore are able to be easily removed.

Although the tape-shaped cover material **6** is affixed to the first principal surface **3***a* of the tape-shaped main body **3** in the first preferred embodiment, this is not a limitation of the present invention. For example, if the first principal surface **3***a* having the plurality of the electronic components **2** with seal materials attached thereto (in the state shown in FIG. **4**F) is wound around a reel, the second principal surface **3***b* of the tape-shaped main body **3** abutting on the inside fulfills the function of the tape-shaped cover material **6**. Such a case eliminates the need for the tape-shaped cover material **6**. In the case of winding the tape-shaped main body **3** around a reel, if the electronic components **5** are made thicker than the tape-shaped main body **3**, the electronic components **5** are pushed against the seal materials **4** and the adhesion strength is increase between the electronic components **5** and the seal materials **4**. As a result, when the electronic components **2** with seal materials are separated from the tape-shaped main body **3**, the electronic components **5** hardly come off.

Although after the cuts **4***c* are formed in the tape-shaped seal material **4**A, the portions **4***b* other than those defining and functioning as the seal materials **4** are separated from the tape-shaped main body **3** in the first preferred embodiment, this is not a limitation of the present invention. The adhesion between the other portions **4***b* and the tape-shaped main body **3**, the size of the cuts **4***c*, etc. may be adjusted such that when the electronic components **2** with seal materials are separated from the tape-shaped main body **3**, the separation is not prevented by the portions **4***b* other than those defining

and functioning as the seal materials **4**. This eliminates the need to separate the other portions **4***b* from the tape-shaped main body **3**.

A method for manufacturing an RFID tag **10** by using the electronic component **2** with a seal material (RFIC element **2** with a seal material) will be described. FIG. **5** is a perspective view of the method for manufacturing the RFID tag **10**. FIG. **6** is a plane view of the antenna base material **11** and the antenna element **12** that are components of the RFID tag **10**. FIG. **7** is a cross-sectional view taken along a line A**2**-A**2** of FIG. **6**. FIG. **8** is a plane view of a state in which the electronic component **2** with a seal material is attached onto the antenna element **12**. FIG. **9** is a cross-sectional view taken along a line A**3**-A**3** of FIG. **8**.

As shown in FIGS. **5** to **9**, the RFID tag **10** is manufactured by attaching the electronic component **2** with a seal material to the antenna element **12** on one principal surface of the antenna base material **11**. The RFID tag **10** is, for example, an RFID tag using the 900 MHz band as a communication frequency.

The antenna base material **11** preferably includes a flexible material such as polyethylene terephthalate (PET) and paper. One principal surface is provided with the antenna element **12** made of copper foil or aluminum foil or silver paste.

The antenna element **12** preferably is formed into a meandering shape, for example, and includes antenna conductors **12***a*, **12***b* defining and functioning as a dipole antenna. A first end portion **12***aa* and a second end portion **12***ba* are an end portion of the antenna conductor **12***a* and an end portion of the antenna conductor **12***b*, respectively, and are spaced away from each other. An interval between the first end portion **12***aa* and the second end portion **12***ba* is identical or substantially identical to an interval between the first terminal electrode **5***a* and the second terminal electrode **5***b* of the electronic component (RFIC element) **5**.

The seal material **4** of the electronic component **2** with a seal material is affixed by the adhesive layer **4***a* to the antenna base material **11** such that the first end portion **12***aa* and the second end portion **12***ba* are brought into contact with the first terminal electrode **5***a* and the second terminal electrode **5***b*, respectively. As a result, the RFID tag **10** is completed.

In this case, the first end portion **12***aa* and the first terminal electrode **5***a* as well as the second end portion **12***ba* and the second terminal electrode **5***b* are not directly fixed to each other although they are electrically connected. Therefore, even when the antenna base material **11** is bent, the first end portion **12***aa* and the first terminal electrode **5***a* as well as the second end portion **12***ba* and the second terminal electrode **5***b* slide at respective connection portions and, therefore, no stress concentrates on the connection portions. Therefore, degradation in reliability of the connection is able to be suppressed between the electronic component **2** with a seal material and the antenna element **12**. Since the electronic component **2** with a seal material defines a convex portion toward the seal material **4** on the terminal electrode side of the electronic component **5**, when the seal material **4** adheres to the antenna base material **11**, a pressure pressing against the antenna base material **11** is applied to the electronic component **5**. As a result, since the first terminal electrode **5***a* and the second terminal electrode **5***b* of the electronic component **5** are pressed against the first end portion **12***aa* and the second end portion **12***ba* of antenna electrodes, stable electric connection is maintained.

Although the antenna conductors **12***a*, **12***b* preferably have a meandering shape in the first preferred embodiment, this is not a limitation of the present invention. The antenna conductors **12***a*, **12***b* may be formed into, for example, a rectangular or substantially rectangular belt shape or other shapes. Although the antenna conductors **12***a*, **12***b* define and function as a dipole antenna, this is not a limitation of the present invention. The antenna conductors **12***a*, **12***b* may define and function as a loop type antenna or may act as other types of antenna.

A method for manufacturing a plurality of the RFID tags **10** by using the carrier tape **1** will be described. FIG. **10** is a side view of an example of the method for manufacturing a plurality of the RFID tags **10** by using the carrier tape **1**. FIG. **11** is an enlarged cross-sectional view of a portion surrounded by a dotted line of FIG. **10**.

First, as shown in FIG. **10**, a supply reel **21** is prepared with the carrier tape **1** wound therearound. The plurality of the antenna base materials **11** including the antenna elements **12** provided thereon as shown in FIG. **16** is connected in series and formed into a tape shape to prepare a supply reel **22** with the plurality of the antenna base materials **11** wound therearound.

The carrier tape **1** is continuously pulled out from the supply reel **21** while pulling out the antenna base materials **11** including the antenna elements **12** thereon from the supply reel **22**, and the carrier tape **1** and the antenna base materials **11** are brought closer to each other.

As shown in FIG. **11**, the tape-shaped main body **3** of the carrier tape **1** is folded (bent) in the vicinity of the antenna base materials **11** to separate the electronic component **2** with a seal material from the tape-shaped main body **3**. At the time of separation, while the electronic component **2** with a seal material is being separated from the tape-shaped main body **3**, the electronic component **2** with a seal material is affixed to the antenna conductors **12***a*, **12***b* of the antenna element **12** transported in the direction intersecting with the transport direction of the carrier tape **1**.

For example, by folding the tape-shaped main body **3** of the carrier tape **1** in the vicinity of the antenna base materials **11**, one end portion of the seal material **4** first peels off from the tape-shaped main body **3**. The one end portion of the seal material **4** adheres by the adhesive force of the adhesive layer **4***a* to the antenna conductor **12***b* of the antenna element **12** transported in the direction intersecting with the transport direction of the carrier tape **1**. Subsequently, as the carrier tape **1** and the antenna element **12** further move, the other end portion of the seal material **4** peels off from the tape-shaped main body **3**. The other end portion of the seal material **4** adheres by the adhesive force of the adhesive layer **4***a* to the antenna conductor **12***a* of the antenna element **12** transported in the direction intersecting with the transport direction of the carrier tape **1**. As a result, the RFID tag **10** shown in FIG. **8** is manufactured. By sequentially performing this operation, a plurality of RFID tags **10** are able to be manufactured.

According to the method for manufacturing an RFID tag according to the first preferred embodiment, the plurality of the electronic components **2** with seal materials is housed in the carrier tape **1** and, therefore, the handleability of the plurality of the electronic components **2** with seal materials is improved. Additionally, since the seal materials **4** necessary for manufacturing the RFID tags **10** are affixed to the second principal surface **3***b* of the tape-shaped main body **3** to retain the electronic components **5**, it is not necessary to dispose another member unnecessary for manufacturing the RFID tags **10** to retain the electronic components **5** in the housing holes **3***c*. Moreover, since the electronic components **2** with seal materials are able to be separated from the

tape-shaped main body **3** by simply folding the tape-shaped main body **3**, manufacturing steps are shortened and manufacturing costs are reduced. An angle of the fold of the tape-shaped main body **3** and a degree of curvature at the folded position may appropriately be set in consideration of the adhesive force between the electronic components **2** with seal materials and the tape-shaped main body **3** etc.

According to the method for manufacturing an RFID tag according to the first preferred embodiment, while the carrier tape **1** is continuously pulled out from the supply reel **21**, the tape-shaped main body **3** of the pulled-out carrier tape **1** is folded at a certain position away from the supply reel **21**. As a result, the plurality of the electronic components **2** with seal materials is sequentially separated from the tape-shaped main body **3** and sequentially affixed to the antenna conductors **12***a*, **12***b* of the antenna elements **12** pulled out from the supply reel **22**. Therefore, for example, the carrier tape **1** can be pulled out at a rate of several dozen m per minute to separate the plurality of the electronic components **5** from the tape-shaped main body **3** at high speed. Consequently, a plurality of the RFID tags **10** are able to be manufactured in shorter time.

Preferably, the seal materials **4** have a rectangular or substantially rectangular shape and, when the electronic components **2** with seal materials are each separated from the tape-shaped main body **3**, a portion in the longitudinal direction of the seal material **4** is first separated. As a result, the electronic components **2** with seal materials are able to be more easily separated from the tape-shaped main body **3**.

The seal materials **4** preferably have rigidity higher than the tape-shaped main body **3**. As a result, when the tape-shaped main body **3** is folded, the separation of the seal materials **4** from the tape-shaped main body **3** is facilitated. Therefore, the seal materials **4** are preferably made of a material having quality or property associated with a larger elastic force (resilience), such as a larger Young's modulus and a greater thickness, than the tape-shaped main body **3**.

The carrier tape **1** after the separation of the electronic components **2** with seal materials may be wound around a winding reel (not shown). In particular, the carrier tape **1** may be transported by a roll-to-roll technique. Similarly, the antenna base materials **11** including the antenna elements **12** thereon may be transported by a roll-to-roll technique.

In the example of manufacturing shown in FIGS. **10** and **11**, the electronic components **2** with seal materials separated from the tape-shaped main body **3** are directly affixed to the antenna conductors **12***a*, **12***b*, this is not a limitation of the present invention. For example, as shown in FIGS. **12** and **13**, the electronic components **2** with seal materials separated from the tape-shaped main body **3** may be affixed to the antenna conductors **12***a*, **12***b* by using a conveyer **23**.

More specifically, the carrier tape **1** pulled out from the supply reel **21** is folded at a certain position away from the supply reel **21** to separate the electronic component **2** with a seal material from the tape-shaped main body **3**. The separated electronic component **2** with a seal material is conveyed by the conveyer **23** to the vicinity of the antenna base material **11** including the antenna element **12** thereon pulled out from the supply reel **22**. As a result, the one end portion of the seal material **4** of the electronic component **2** with a seal material is affixed to the antenna conductor **12***b*, and the other end portion of the seal material **4** is affixed to the antenna conductor **12***a*. By sequentially performing this operation, a plurality of RFID tags **10** are able to be manufactured.

According to this configuration, the adjustment of machinery is made easier and the electronic components **2** with seal materials are able to be more accurately affixed to the antenna conductors **12***a*, **12***b*.

The conveyer **23** may be an apparatus such as a suction head instead of a belt-conveyor-type apparatus as shown in FIGS. **12** and **13**. In particular, the electronic component **2** with a seal material separated from the tape-shaped main body **3** may be sucked by a suction head and affixed to the antenna conductors **12***a*, **12***b* of the antenna element **12**.

Description will be made of a specific configuration of an RFIC element **100** that is an example of the electronic component **5**.

FIG. **14** is a perspective view of the RFIC element **100**. The RFIC element **100** preferably is an RFIC element corresponding to a communication frequency of, for example, the 900 MHz band, i.e., the UHF band. The RFIC element **100** includes a multilayer substrate **120** with a principal surface defining a rectangle. The multilayer substrate **120** has flexibility. For example, the multilayer substrate **120** has a structure of a laminated body acquired by laminating flexible resin insulation layers of polyimide, liquid crystal polymer, etc. The insulation layers made of these materials have the permittivity smaller than that of ceramic base material layers represented by LTCC.

Hereinafter, for convenience of description, a longitudinal direction of the multilayer substrate **120** is indicated by an X-axis, a width direction of the multilayer substrate **120** is indicated by a Y-axis, and a thickness direction of the multilayer substrate **120** is indicated by a Z-axis.

FIG. **15** is a transverse cross-sectional view of the RFIC element shown in FIG. **14**. FIG. **16**A is a plane view of an upper insulation layer of the multilayer substrate **120** viewed from directly above. FIG. **16**B is a plane view of an intermediate insulation layer of the multilayer substrate **120** viewed from directly above. FIG. **16**C is a plane view of a lower insulation layer of the multilayer substrate **120** viewed from directly above. FIG. **17**A is a cross-sectional view of the insulation layer shown in FIG. **16**A taken along a line B**1**-B**1**. FIG. **17**B is a cross-sectional view of the insulation layer shown in FIG. **16**B taken along a line B**2**-B**2**. FIG. **17**C is a cross-sectional view of the insulation layer shown in FIG. **16**C taken along a line B**3**-B**3**.

As shown in FIG. **15**, an RFIC chip **160** and a power feeding circuit **180** are built into the multilayer substrate **120**. A first terminal electrode **140***a* and a second terminal electrode **140***b* are provided on one principal surface of the multilayer substrate **120**.

The RFIC chip **160** has a structure in which various elements are built into a hard semiconductor substrate made of a semiconductor such as silicon. The both principal surfaces of the RFIC chip **160** are preferably square or substantially square. As shown in FIG. **16**C, a first input/output terminal **160***a* and a second input/output terminal **160***b* are provided on the other principal surface of the RFIC chip **160**. The RFIC chip **160** is located at the center in each of the X-, Y-, and Z-axes inside the multilayer substrate **120** in a posture in which the sides of the square extends along the X-axis or the Y-axis and the one principal surface and the other principal surface face the positive side and the negative side, respectively, in the Z-axis direction.

The power feeding circuit **180** includes a coil conductor **200** and interlayer connection conductors **240***a*, **240***b*. The coil conductor **200** includes coil patterns **200***a* to **200***c* shown in FIG. **16**B or **16**C. A portion of the coil pattern **200***a* includes a first coil portion CIL**1**. A portion of the coil pattern **200***b* includes a second coil portion CIL**2**. Portions of the coil pattern **200***c* include a third coil portion CIL**3** and a fourth coil portion CIL**4**.

The first coil portion CIL**1**, the third coil portion CIL**3**, and the interlayer connection conductor **240***a* are arranged in the Z-axis direction at positions on the negative side in the X-axis direction. The second coil portion CIL**2**, the fourth coil portion CIL**4**, and the interlayer connection conductor **240***b* are arranged in the Z-axis direction at positions on the positive side in the X-axis direction.

When the multilayer substrate **120** is viewed in Z-axis direction, the RFIC chip **160** is located between the first coil portion CIL**1** and the second coil portion CIL**2**. When the multilayer substrate **120** is viewed in Y-axis direction, the RFIC chip **160** is located between the third coil portion CIL**3** and the fourth coil portion CIL**4**.

The first terminal electrode **140***a* is disposed at a position on the negative side in the X-axis direction. The second terminal electrode **140***b* is disposed at a position on the positive side in the X-axis direction. Both the first terminal electrode **140***a* and the second terminal electrode **140***b* are made of flexible copper foil into a strip shape. The first terminal electrode **140***a* and the second terminal electrode **140***b* have the respective principal surface sizes identical or substantially identical to each other. The short sides of the first terminal electrode **140***a* and the second terminal electrode **140***b* extend in the X-axis direction. The long sides of the first terminal electrode **140***a* and the second terminal electrode **140***b* extend in the Y-axis direction.

Therefore, when the multilayer substrate **120** is viewed in the Y-axis direction, the RFIC chip **160** is interposed between a portion of the power feeding circuit **180** and another portion of the power feeding circuit **180**. When the multilayer substrate **120** is viewed in the X-axis direction, the RFIC chip **160** overlaps with the power feeding circuit **180**. In a planar view of the multilayer substrate **120**, the power feeding circuit **180** partially overlaps with each of the first and second terminal electrodes **140***a*, **140***b*.

As shown in FIGS. **16**A to **16**C, the multilayer substrate **120** includes three laminated sheet-shaped insulation layers **120***a* to **120***c*. The insulation layer **120***a* is located at an upper position, the insulation layer **120***b* is located at an intermediate position, and the insulation layer **120***c* is located at a lower position.

The first terminal electrode **140***a* and the second terminal electrode **140***b* are provided on one principal surface of the insulation layer **120***a*. At the center position of one principal surface of the insulation layer **120***b*, a rectangular or substantially rectangular through-hole HL**1** is formed, reaching the other principal surface. The through-hole HL**1** has a size sufficient to contain the RFIC chip **160**. The coil pattern **200***c* extending in a belt shape extends around the through-hole HL**1** on the one principal surface of the insulation layer **120***b*. The coil pattern **200***c* is made of copper foil having flexibility.

One end portion of the coil pattern **200***c* is disposed at a position overlapping with the first terminal electrode **140***a* in the planar view and is connected to the first terminal electrode **140***a* by an interlayer connection conductor **220***a* extending in the Z-axis direction. The other end portion of the coil pattern **200***c* is disposed at a position overlapping with the second terminal electrode **140***b* in the planar view and is connected to the second terminal electrode **140***b* by an interlayer connection conductor **220***b* extending in the Z-axis direction. The interlayer connection conductors **220***a*, **220***b* include hard metal bulks containing Sn as a main component.

Assuming that the one end portion of the coil pattern **200***c* is a starting point, the coil pattern **200***c* extends around the one end portion twice in the counterclockwise direction, extends to near the end portion of the negative side in the Y-axis direction, and then extends into the positive side in the X-axis direction. The coil pattern **200***c* bends near the end portion of the positive side in the X-axis direction toward the positive side in the Y-axis direction and extends around the other end portion twice in the counterclockwise direction before reaching the other end portion.

The coil patterns **200***a*, **200***b* extending in a belt shape are provided on one principal surface of the insulation layer **120***c*. The coil patterns **200***a*, **200***b* are made of copper foil having flexibility. In a planar view of the insulation layers **120***b*, **120***c*, one end portion of the coil pattern **200***a* is disposed at a position somewhat on the negative side in the Y-axis direction as compared to the one end portion of the coil pattern **200***c*, and the other end portion of the coil pattern **200***a* (a first coil end T**1**) is disposed at a position overlapping with a corner portion on the negative side in the X-axis direction and the positive side in the Y-axis direction out of the four corner portions of the rectangular through-hole HL**1**.

One end portion of the coil pattern **200***b* is disposed at a position somewhat on the negative side in the Y-axis direction as compared to the other end portion of the coil pattern **200***c*. The other end portion of the coil pattern **200***b* (a second coil end T**2**) is disposed at a position overlapping with a corner portion on the positive side in the X-axis direction and the positive side in the Y-axis direction out of the four corner portions of the rectangular or substantially rectangular through-hole HL**1**. Both the first coil end T**1** and the second coil end T**2** are rectangular or substantially rectangular in the planar view of the insulation layer **120***c*.

Assuming that the one end portion of the coil pattern **200***a* is a starting point, the coil pattern **200***a* extends around the one end portion 2.5 times in the clockwise direction and subsequently bends toward the negative side in the Y-axis direction to reach the other end portion. Similarly, assuming that the one end portion of the coil pattern **200***b* is a starting point, the coil pattern **200***b* extends around the one end portion 2.5 times in the anticlockwise direction and subsequently bends toward the negative side in the Y-axis direction to reach the other end portion. The one end portion of the coil pattern **200***a* is connected to the one end portion of the coil pattern **200***c* by the interlayer connection conductor **240***a* extending in the Z-axis direction. The one end portion of the coil pattern **200***b* is connected to the other end portion of the coil pattern **200***c* by the interlayer connection conductor **240***b* extending in the Z-axis direction. The interlayer connection conductors **240***a*, **240***b* include hard metal bulks containing Sn as a main component.

In the planar view of the insulation layers **120***b*, **120***c*, a section of the coil pattern **200***a* overlaps with a section of the coil pattern **200***c*, and a section of the coil pattern **200***b* overlaps with another section of the coil pattern **200***c*. Between the overlapping sections of the coil patterns **200***a*, **200***c*, the section of the coil pattern **200***a* is defined as a "first coil portion CIL**1**" and the section of the coil pattern **200***c* is defined as a "third coil portion CIL**3**." Between the overlapping sections of the coil patterns **200***b*, **200***c*, the section of the coil pattern **200***b* is defined as a "second coil portion CIL**2**" and the section of the coil pattern **200***c* is defined as a "fourth coil portion CIL**4**." The position of the one end portion of the coil pattern **200***a* or the one end portion of the coil pattern **200***c* is defined as a "first position P**1**" and the position of the one end portion of the coil pattern **200***b* or the other end portion of the coil pattern **200***c* is defined as a "second position P**2**."

Rectangular or substantially rectangular dummy conductors **260***a*, **260***b* are provided on the one principal surface of the insulation layer **120***c*. The dummy conductors **260***a*, **260***b* are made of copper foil having flexibility. In the planar view of the insulation layers **120***b*, **120***c*, the dummy conductors **260***a*, **260***b* are disposed to overlap with two respective corner portions arranged in the X-axis direction on the negative side in the Y-axis direction out of the four corner portions of the rectangular or substantially rectangular through-hole HL**1**.

The RFIC chip **160** is mounted on the insulation layer **120***c* such that the four corner portions of the other principal surface respectively face the first coil end T**1**, the second coil end T**2**, and the dummy conductors **260***a*, **260***b*. The first input/output terminal **160***a* is disposed on the other principal surface of the RFIC chip **160** to overlap with the first coil end T**1** in the planar view. Similarly, the second input/output terminal **160***b* is disposed on the other principal surface of the RFIC chip **160** to overlap with the second coil end T**2** in the planar view.

As a result, the RFIC chip **160** is connected to the first coil end T**1** by the first input/output terminal **160***a* and is connected to the second coil end T**2** by the second input/output terminal **160***b*.

This thickness of the insulation layers **120***a* to **120***c* preferably is about 10 μm or greater and about 100 μm or less, for example. Therefore, the RFIC chip **160** and the power feeding circuit **180** built into the multilayer substrate **120** can be seen through on the outside. Therefore, the connection state (presence of a broken wire) of the RFIC chip **160** and the power feeding circuit **180** is easily confirmed.

FIG. **18** is a diagram of an equivalent circuit of the RFIC element **100** configured as described above. In FIG. **18**, an inductor L**1** corresponds to the first coil portion CIL**1**. An inductor L**2** corresponds to the second coil portion CIL**2**. An inductor L**3** corresponds to the third coil portion CIL**3**. An inductor L**4** corresponds to the fourth coil portion CIL**4**. The characteristics of impedance matching by the power feeding circuit **180** are specified by the values of the inductors L**1** to L**4**.

One end portion of the inductor L**1** is connected to the first input/output terminal **160***a* disposed on the RFIC chip **160**. One end portion of the inductor L**2** is connected to the second input/output terminal **160***b* disposed on the RFIC chip **160**. The other end portion of the inductor L**1** is connected to one end portion of the inductor L**3**. The other end portion of the inductor L**2** is connected to one end portion of the inductor L**4**. The other end portion of the inductor L**3** is connected to the other end portion of the inductor L**4**. The first terminal electrode **140***a* is connected to a connection point between the inductors L**1**, L**3**. The second terminal electrode **140***b* is connected to a connection point between the inductors L**2**, L**4**.

As can be seen from the equivalent circuit shown in FIG. **18**, the first coil portion CIL**1**, the second coil portion CIL**2**, the third coil portion CIL**3**, and the fourth coil portion CIL**4** are wound to provide magnetic fields in phase and are connected in series to each other. Therefore, the magnetic fields are generated toward a direction indicted by arrows of FIG. **19** at a certain time point. On the other hand, the magnetic fields are generated toward a direction opposite to the direction indicted by the arrows of FIG. **19** at another time point.

As can be seen from FIGS. **16**B and **16**C, the first coil portion CIL**1** and the third coil portion CIL**3** have the same or substantially the same loop shape and a same first winding axis. Similarly, the second coil portion CIL**2** and the fourth coil portion CIL**4** have the same or substantially the same loop shape and a same second winding axis. The first winding axis and the second winding axis are disposed at positions where the RFIC chip **160** is interposed therebetween.

Therefore, the first coil portion CIL**1** and the third coil portion CIL**3** are magnetically and capacitively coupled. Similarly, the second coil portion CIL**2** and the fourth coil portion CIL**4** are magnetically and capacitively coupled.

As can be understood from the description, the RFIC chip **160** includes the first input/output terminal **160***a* and the second input/output terminal **160***b* and is built into the multilayer substrate **120**. The power feeding circuit **180** includes the coil patterns **200***a* to **200***c* and is built into the multilayer substrate **120**. Among these, the coil pattern **200***a* has the other end portion (the first coil end T**1**) connected to the first input/output terminal **160***a*, and the coil pattern **200***b* has the other end portion (the second coil end T**2**) connected to the second input/output terminal **160***b*. The first terminal electrode **140***a* and the second terminal electrode **140***b* are disposed on the one principal surface of the multilayer substrate **120**. The first terminal electrode **140***a* is connected to the one end portion of the coil pattern **200***a* (the first position P**1**). The second terminal electrode **140***b* is connected to the one end portion of the coil pattern **200***b* (the second position P**2**).

The first coil portion CIL**1** is present in a section from the first coil end T**1** to the first position P**1** and has the first winding axis in the direction intersecting with the one principal surface of the multilayer substrate **120**. The second coil portion CIL**2** is present in a section from the second coil end T**2** to the second position P**2** and has the second winding axis in the direction intersecting with the one principal surface of the multilayer substrate **120**. The third coil portion CIL**3** is disposed to overlap with the first coil portion CIL**1** in the planar view. The fourth coil portion CIL**4** is disposed to overlap with the second coil portion CIL**2** in the planar view. The first coil portion CIL**1**/the third coil portion CIL**3** and the second coil portion CIL**2**/the fourth coil portion CIL**4** are disposed at positions where the RFIC chip **160** is interposed therebetween. The multilayer substrate **120** has the power feeding circuit **180** that performs impedance matching between the antenna element **12** and the RFIC chip **160** as well as the RFIC chip **160** built-in.

The RFIC chip **160** includes the semiconductor substrate. Therefore, the RFIC chip **160** acts as a ground or a shield for the first coil portion CIL**1**, the second coil portion CIL**2**, the third coil portion CIL**3**, and the fourth coil portion CIL**4**. Consequently, the first coil portion CIL**1** and the second coil portion CIL**2** as well as the third coil portion CIL**3** and the fourth coil portion CIL**4** are hardly magnetically or capacitively coupled to each other. This enables the reduction in the risk of narrowing the passband of communication signals.

An example of attaching the RFIC element **100** onto the antenna conductors **12***a*, **12***b* by conductive bonding materials **13***a*, **13***b* will be described. FIG. **20** is a diagram of distribution of rigid and flexible regions in the RFIC element **100**. FIG. **21** is a diagram of a bent state of an RFID tag including the RFIC element **100** attached to the antenna conductors **12***a*, **12***b*.

As described above, the multilayer substrate **120**, the coil patterns **200***a* to **200***c*, the first terminal electrode **140***a*, and the second terminal electrode **140***b* include members having flexibility. On the other hand, the interlayer connection conductors **220***a*, **220***b*, **240***a*, **240***b* and the substrate of the

RFIC chip **160** include hard members. The first terminal electrode **140***a* and the second terminal electrode **140***b* are comparatively large in size and therefore less flexible. If a plating film of Ni/Au or Ni/Sn etc. is applied to the first terminal electrode **140***a* and the second terminal electrode **140***b*, the first terminal electrode **140***a* and the second terminal electrode **140***b* are further reduced in flexibility.

As a result, rigid regions and flexible regions are provided in the RFIC element **100** as shown in FIG. **20**. More specifically, the regions disposed with the first terminal electrode **140***a*, the second terminal electrode **140***b*, and the RFIC chip **160** are define as the rigid regions, and the other regions are defined as the flexible regions. Particularly, since the first terminal electrode **140***a* and the second terminal electrode **140***b* are disposed at positions away from the RFIC chip **160**, the flexible regions are located between the first terminal electrode **140***a* and the RFIC chip **160** and between the second terminal electrode **140***b* and the RFIC chip **160**.

Therefore, if the RFID tag having the RFIC element **100** affixed to the antenna conductors **12***a*, **12***b* of the antenna base material **11** is affixed to a curved surface, the RFIC element **100** is bent as shown in FIG. **21**, for example.

FIG. **22** is a diagram of an example in which a current flows through an equivalent circuit of the RFID tag of FIG. **21**. FIG. **23** is a graph of an example of resonance frequency characteristics of the RFID tag of FIG. **21**

As shown in FIG. **22**, the RFIC chip **160** itself has a parasitic capacitance (stray capacitance) Cp present between the first input/output terminal **160***a* and the second input/output terminal **160***b*. Therefore, two resonances are generated in the RFIC element **100**. The first resonance is the resonance generated in a current path including the antenna conductors **12***a*, **12***b* and the inductors L**3**, L**4**. The second resonance is the resonance generated in a current path (current loop) including the inductors L**1** to L**4** and the parasitic capacitance Cp. These two resonances are coupled by the inductors L**3** to L**4** shared by the current paths. Two respective currents I**1** and I**2** corresponding to the two resonances flow as indicated by a dotted line in FIG. **22**.

Both a first resonance frequency and a second resonance frequency are affected by the inductors L**3** to L**4**. A difference of several dozen MHz (specifically, about 5 MHz or more to about 50 MHz or less, for example) is generated between the first resonance frequency and the second resonance frequency. The resonance frequency characteristics thereof are represented by curves I and II in FIG. **21**. By combining the two resonances having such resonance frequencies, broadband resonance frequency characteristics are produced as indicated by a curve III in FIG. **23**.

Second Preferred Embodiment

FIG. **24** is a perspective view of a general configuration of an electronic component **2**A with a seal material according to a second preferred embodiment of the present invention. FIG. **25** is a plane view of a state of the electronic component **2**A with a seal material of FIG. **24** attached to the antenna element **12** of the antenna base material **11**. The second preferred embodiment is different from the first preferred embodiment in that a seal material **41** of the electronic component **2**A with a seal material is smaller in size than the seal material **4**.

As shown in FIG. **24**, the seal material **41** preferably has a rectangular or substantially rectangular belt shape. The seal material **41** is attached to a portion of the fixation surface of the electronic component **5** to extend in a direction intersecting with (e.g., perpendicular or substantially perpendicular to) the longitudinal direction of the electronic component **5**.

The seal material **41** shaped and sized as above also ensures the electric connection between the terminal electrodes **5***a*, **5***b* of the electronic component **5** and the antenna conductors **12***a*, **12***b*, and eliminates the need for direct fixation using ultrasonic bonding etc. or fixation using a bonding material.

The seal material **41** is able to be manufactured using the manufacturing steps for the carrier tape described above with reference to FIG. **4**D by forming cuts to separate a portion defining and functioning as the seal material **41** including a portion partially overlapping with each of the housing holes **3***c* in a planar view from the other portions. FIG. **26** is a bottom view of a state in which the portions other than those defining and functioning as the seal materials **41** are separated from the tape-shaped main body **3** after the formation of the cuts. In this case, the seal materials **41** do not completely cover the housing holes **3***c*, generating portions exposing the housing holes **3***c*.

Although the one seal material **41** preferably is disposed for each of the electronic components **5** in the second preferred embodiment, this is not a limitation of the present invention. For example, the two or more seal materials **41** may be disposed for each of the electronic components **5**.

Third Preferred Embodiment

FIG. **27** is a perspective view of a general configuration of an electronic component **2**B with a seal material according to a third preferred embodiment of the present invention. FIG. **28** is a plane view of a state of the electronic component **2**B with a seal material of FIG. **27** attached to an antenna element **12**B of an antenna base material **11**B. The third preferred embodiment is different from the first preferred embodiment in that a seal material **42** of the electronic component **2**B with a seal material is smaller in width than the seal material **4** and that antenna conductors **12***a*B, **12***b*B of the antenna element **12**B preferably have an elongated rectangular or substantially rectangular belt shape.

As shown in FIG. **27**, the seal material **42** is attached to the fixation surface of the electronic component **5** to extend in the longitudinal direction of the electronic component **5**. The length of the seal material **42** in the transverse direction and the length of the electronic component **5** in the transverse direction are the same or substantially the same. The seal material **42** has the length in the longitudinal direction longer than the length of the electronic component **5** in the longitudinal direction and is sized to protrude from both end portions of the electronic component **5** in the longitudinal direction.

The seal material **42** shaped and sized as above also ensures the electric connection between the terminal electrodes **5***a*, **5***b* of the electronic component **5** and the antenna conductors **12***a*, **12***b*, and eliminates the need for direct fixation using ultrasonic bonding etc. or fixation using a bonding material. Since the width of the electronic component **2**B with a seal material is able to be narrowed, the widths of the antenna base material **11**B and the antenna conductors **12***a*B, **12***b*B of the antenna element **12**B are able to be narrowed so that, for example, the component is able to be affixed to an outer circumferential surface of a circular plate-shaped disk such as a DVD.

In the third preferred embodiment, the antenna element **12**B defines and functions as a dipole antenna. The antenna conductors **12***a*B, **12***b*B have common widths and lengths.

The width of the antenna conductors **12***a*B, **12***b*B is smaller than the width of the antenna base material **11**B. The width of the antenna base material **11**B is about 1 mm, for example. The length of the antenna conductors **12***a*B, **12***b*B is less than a half of the length of the antenna base material **11**B.

The seal material **42** is able to be manufactured in the manufacturing steps for the carrier tape described above with reference to FIG. **4**D by forming cuts to separate a portion defining and functioning as the seal material **42** including a portion partially overlapping with each of the housing holes **3***c* in a planar view from the other portions. FIG. **29** is a bottom view of a state in which the portions other than those defining and functioning as the seal materials **42** are separated from the tape-shaped main body **3** after the formation of the cuts. In this case, the seal materials **42** do not completely cover the housing holes **3***c*, generating portions exposing the housing holes **3***c*.

The preferred embodiments of the present invention are illustrative and the constituent elements described in the different preferred embodiments can be partially replaced or combined. In the second and later preferred embodiments, the details common to the first preferred embodiment are not described and only the differences are described. Particularly, the same actions and effects of the same constituent elements are not repeatedly mentioned for each of the preferred embodiments.

Although the present invention has been sufficiently described in terms of preferred embodiments with reference to the accompanying drawings, various modifications and corrections are apparent to those skilled in the art. It should be understood that such modifications and corrections are included in the present invention without departing from the scope of the present invention according to the accompanying claims.

Since the handleability of the electronic components with seal materials is improved, preferred embodiments of the present invention are useful for manufacturing of RFID tags, a carrier tape used in the manufacturing, and a method for manufacturing the same.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A carrier tape housing a plurality of electronic components with seal materials, the carrier tape comprising:

a tape-shaped main body including a first principal surface and a second principal surface and including a plurality of housing holes penetrating from the first principal surface to the second principal surface along a longitudinal direction;

a plurality of seal materials each having an adhesive layer on one principle surface and affixed to the second principal surface of the tape-shaped main body such that the adhesive layer is exposed in at least a portion of each of the housing holes; and

a plurality of chip-shaped electronic components housed in the respective housing holes and fixed to the adhesive layers of the respective seal materials; wherein

the seal materials have rigidity higher than the tape-shaped main body.

2. The carrier tape of claim **1**, wherein the electronic components are components defining RFID tags and each includes an RFIC chip and a substrate with the RFIC chip mounted thereon.

3. The carrier tape of claim **2**, wherein the substrate is a substrate of an RFID tag and includes a power feeding circuit that performs impedance matching between an antenna element and the RFIC chip.

4. The carrier tape of claim **1**, wherein a tape-shaped cover material is affixed to the first principal surface of the tape-shaped main body to cover the plurality of the housing holes housing the electronic components.

5. The carrier tape of claim **1**, wherein the electronic component includes a terminal electrode on a surface on the side opposite to a fixation surface fixed to the adhesive layer of the seal material.

6. A carrier tape housing a plurality of electronic components with seal materials, the carrier tape comprising:

a tape-shaped main body including a first principal surface and a second principal surface and including a plurality of housing holes penetrating from the first principal surface to the second principal surface along a longitudinal direction;

a plurality of seal materials each having an adhesive layer on one principle surface and affixed to the second principal surface of the tape-shaped main body such that the adhesive layer is exposed in at least a portion of each of the housing holes; and

a plurality of chip-shaped electronic components housed in the respective housing holes and fixed to the adhesive layers of the respective seal materials; wherein

the electronic components are components defining RFID tags and each includes an RFIC chip and a substrate with the RFIC chip mounted thereon; and

the substrate is a substrate of an RFID tag and includes a power feeding circuit that performs impedance matching between an antenna element and the RFIC chip.

7. The carrier tape of claim **6**, wherein the seal materials have rigidity higher than the tape-shaped main body.

8. The carrier tape of claim **6**, wherein a tape-shaped cover material is affixed to the first principal surface of the tape-shaped main body to cover the plurality of the housing holes housing the electronic components.

9. The carrier tape of claim **6**, wherein the electronic component includes a terminal electrode on a surface on the side opposite to a fixation surface fixed to the adhesive layer of the seal material.

* * * * *